REPORT OF BOTANIST.

L. R. JONES.

The study of fungous diseases of plants and of remedies for these diseases has been the principal subject of attention during the past year. A fair start has also been made toward the collection of a herbarium.

The absence of the Botanist during several weeks of the summer, prevented the undertaking of any experiments requiring his personal supervision during this time.*

Special attention will be given to the diseases of plants in the future work also of this department. These diseases are generally caused by parasitic plants or *fungi*, and since little has been said in the preceding reports of the Station, about these fungi, it will be well to state here a few facts as to their general nature and the nature and amount of the injuries caused by them.

The injuries to plants due to insects is comparitively well appreciated, but it is not so generally understood that there is scarcely a plant about us, wild or cultivated, that is not preyed upon and more or less seriously injured by parasitic plants or fungi.

Most botanists themselves have only begun to appreciate the extent of these ravages within a few years. An especial incentive has been given to the study of plant diseases within these few years by the discoveries of various compounds like the Bordeaux Mixture, which can be used to check the development and spread of many of them.

WHAT IS THE NATURE OF A FUNGUS?

It is easy to understand the nature of parasitic animals, *i. e.* animals that live upon or in other animals. Lice, Ticks and Tapeworms are familiar examples.

These parasites, as all know, are just as truly animals as are the cattle, sheep, or other animals upon or within which they live. These parasites have, however, because of their peculiar mode of life, become so changed from ordinary animals that they are no longer able to gain an independent livelihood. Their organs of locomotion are dwarfed, through disuse, and their digestive organs changed to suit the delicate, ready-prepared food which they draw from the veins and tissues of their host.†

* The experiments in spraying potatoes were carried out by Mr. Minott, Horticulturist.

† The animal or plant upon or within which a parasite lives is called the *host* of the parasite.

While the locomotive and digestive organs of these parasitic animals are poorly developed, their reproductive organs are correspondingly more developed than those of ordinary animals. The tape-worm, for example, is capable of producing eggs.

Parasitic plants, or Fungi, occupy about the same place in the vegetable kingdom that these parasitic animals occupy in the animal kingdom. These parasitic plants or fungi grow upon, or even within higher plants, feed upon their juices or tissues, and like the parasitic animals, while their other organs are poorly developed their re-productive organs are marvellously active.

Mushrooms or "toad-stools" and puff-balls are the largest and best known of these fungi. It may be well to note briefly the method of growth and development of one of these, the puff-ball for example, since it will illustrate much about the growth and nature of all fungi.*

The portion of the puff-ball which appears above ground is not the whole of the plant, of course, but merely the fruiting portion. Underneath the ground if we examine carefully, we find minute white threads extending away from the puff-ball in all directions like the roots from the base of a stalk of corn. This system of threads is called the *mycelium* of the puff-ball. This mycelium makes up the whole body of the puff-ball plant except the fruiting portion already mentioned; hence it really corresponds in function to both the roots and the leaves of the higher plants.

After the puff-ball becomes mature, if it be broken open an immense cloud of dusty matter is set free. This is familiar to every child. This dust consists largely of the *spores* of the plants which correspond in function to the seeds of higher plants. These spores are produced in immense numbers and being so small are scattered in all directions by the winds. When one of these spores falls in a warm, moist place, it germinates and thus gives rise to a new growth of mycelium. If there is enough decaying vegetable matter for it to feed upon, this mycelium grows rapidly and soon sends up into the air in its turn, its fruiting branches which ripen into puff-balls as before, and a second crop of spores is produced and scattered abroad.

The general structure of the puff-ball plant, and of fungi in general, is then really simpler than that of the higher plants, consisting of 1st—A *mycelium* of minute white or transparent threads which act as feeders, and 2nd—Fruiting branches sent out from this mycelium upon which *spores* are produced. It is to be remembered that in all fungi these spores are *extremely small* and are *produced in immense numbers.*

In some fungi the mycelium grows on the surface of the substance it feeds upon. In the common bread mold the glistening white threads of

*As said before, fungi always feed upon other plants. Many fungi grow upon living plants but puff-balls feed upon decaying vegetable matter.

the mycelium grows upon the surface of the bread and often forms a thick cottony mass before any of the black spores are produced. It is interesting and very instructive to place a piece of moistened bread under a tumbler and watch the growth of this mycelium and the development of the spores.

The green mold of cheese is a fungus of similar general habits. With many other fungi, the mycelium can live only within the tissues of certain plants. Many of these latter are familiar to every farmer, and are sources of serious loss to him every year. The common smut on corn is simply a great mass of black spores, similar to the spores produced in the puff-ball. But while the mycelium of the puff-ball grows in decaying vegetable matter the mycelium of the corn smut makes its home in the tissues of the corn plant, and draws its nourishment from them. The smuts of oats, barley, and other grains, are likewise the spores of other closely related fungi. The common red rust found so plentifully on the stalks and leaves of oats and other grains, is again the spores of a fungus the mycelium of which grows within the grain plant. The black rust of these grains, which usually appears a little later in the season than the red rust, is another kind of spore produced by the same fungus. These black spores have thicker coats and live through the winter, while the red spores are killed by the frost.

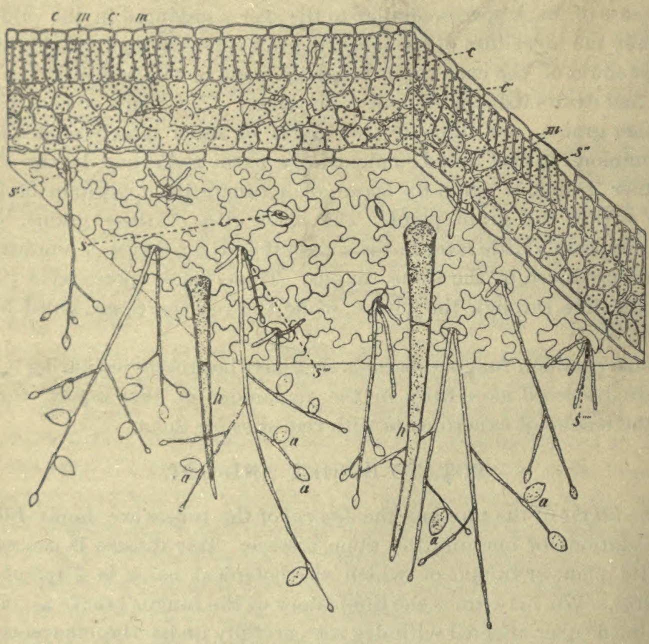
Some common fungous diseases that have been observed during the past year are discussed more fully in the remainder of this report, together with the results of experiments with remedies for them.

POTATO BLIGHT AND ROT.

The *blight* of the tops and the *dry rot* of the tubers are simply different manifestations of one and the same disease. This disease is caused by a parasitic plant or fungus of which the botanical name is *Phytophthora infestans.* We may trace the life-history of the fungus briefly as follows: Examine a tuber affected with dry rot carefully under the microscope and the mycelium of the fungus may be found running through it. The dry rot * is simply the death of the tissues of the tuber from exhaustion as a result of this mycelium feeding upon them. As soon as the tuber dies the mycelium of the fungus dies, but until the tuber is killed the fungus lives and spreads through it. If the tuber is stored in a cool cellar the fungus may not grow fast enough to kill the tissues of the tuber, hence although the mycelium of the fungus is within the tuber, there may be no indications of its presence. Let a tuber affected with dry rot be planted, or even such a tuber as just described, which contains the fungus but does not show any

* The *wet rot* often follows this dry rot, especially if the tubers are in a damp place. This wet rot is the ordinary decay of dead vegetables. It follows the dry rot because the fungus of the dry rot has killed the tissues of the tuber. If the tuber is killed by frost or any other agency the wet rot follows in the same way.

signs of its presence—and many such are planted in Vermont every year. As the potato sprout grows, the mycelium of the fungus grows and penetrates stem, branches and leaves of the potato plant. When the conditions of weather are favorably warm and moist the mycelium sends fruiting branches out through the breathing-pores (stomata) on the underside of the potato leaves, and upon these branches spores are produced in countless profusion. These spore-bearing branches and spores form the whitish patches which look like frost on the underside of the blighting leaves.



The above figure represents, considerably magnified, a small square piece cut from such a potato leaf.

The letters at the upper side of the figure, c, m, c^1, m, c, c^1, m, s^{11}, indicate the cut edges of the piece of leaf. On the under side of the leaf are shown, at h, h, two of the hairs which are so abundant on the under sides of all potato leaves. The slenderer branching stems between are the fruiting branches of the fungus, bearing numerous spores, at a, a, etc. It will be seen that the body of the leaf is made up of cells rather globular in shape (c^1, c^1). These are very important cells to the plant, since in them all the starch of the plant is made. Between these cells in many places the thread-like mycelium of the fungus can be traced, as at m, m, m. It will be evident how this mycelium pushing thus between the cells can draw its food from

them. The lower surface of the leaf is seen to be covered with a single layer of thin protective cells. These are somewhat like pavement slabs or bricks, except that the edges are dovetailed together instead of being straight. Through this layer of cells there are various openings at s, s^1, s^{11}, s^{111}, s^{1111}, etc. These are the breathing-pores or stomata. The pore or stoma at s, and another a little further to the right, are shown in their natural healthy condition, but through all the others (at s^1, s^{11}, s^{111}, s^{1111}, etc.), the branches of the fungus are growing. At s^1 and s^{11}, two of the pores or stomata are cut across, showing how the fruiting branches of the fungus grow out from the mycelium which is within the leaf. At s^{11} and s^{1111} the fruiting branches are just starting; at s^1 one is seen a little more developed, with four young egg-shaped spores forming on it; at s^{111} and some other of the stomata older, fully developed branches are seen with full grown spores at a, a, a, a, a, and other points.

The mycelium of the fungus makes an especial drain on the tissues of the plant for food at the time of ripening its spores, and soon kills the leaf at the spot where the spores are produced. These black spots on the leaves in July and August are a familiar sight to every potato grower in the State. They are an indication that the blight is present and ready to spread rapidly if the weather favors the rapid production and germination of the spores. The spores from a single affected plant are enough to carry the blight to a whole potato field in a short time. Striking proof that the blight does spread in this way from a single plant or a few plants is often seen. In the Experiment Station potato field, in 1889, the blight broke out first in one corner and spread diagonally accross the field, *following the direction of the wind.**

It is plain now that if any mixture is sprayed upon the potato leaves which will kill the spores the spread of the blight will be checked. It has been demonstrated by repeated trials during the last few years that the mixture of copper sulphate (blue vitriol or blue-stone) and lime, known as the *Bordeaux Mixture* is a very effective remedy when used in this way.

The Bordeaux Mixture consists of four pounds of copper sulphate (blue vitriol), six pounds of freshly slacked lime and twenty-two gallons of water. Full directions for making and applying this Mixture have been published in Bulletin No. 24.

The value of Bordeaux Mixture as a remedy for the blight and rot was evident in our trial of it in 1889.† Experiments were undertaken last year to determine the relative effect of one, two, and four applications. The regular experimental plots of the Horticulturist, described in his present report, contained over 200 varieties of potatoes. These were all sprayed four times—July 8th, July 18th, August 1st, and August 18th. In all

* See Newspaper Bul. No. 2, and Bul. No. 24, p. 21.

† See Newspaper Bulletin No. 2, and Annual Report, '89, p. 117.

cases Paris Green was added to the Mixture for the potato beetle. The amount of rot in each variety is given in the Horticulturist's report. Fifty of the more commonly known varieties are selected for comparison in the table on page 136. The average amount of rot in these fifty varieties is 5.3%.

An adjoining plot was sprayed so as to test the effects of fewer applications. One end, (the south end), was sprayed once, August 18th, just before the blight appeared; the other end of the same plot, (the north end), was sprayed twice, August 18th and September 16th; the middle of the plot was not sprayed at all.†

The effects of the sprayings were very marked. The potato plants not sprayed blighted badly, and within two weeks were all dead. The ones sprayed blighted some but remained comparatively green until killed by the frost.

Those sprayed twice looked somewhat better than those sprayed once, although the difference in the appearance of the vines was not very marked.

The potatoes were all dug October 11th. One row of each variety was saved apart for examination, the tubers from each end and from the middle being kept by themselves. November 22d these were carefully examined, sorted and weighed. The results are given in detail on page 135.

Taking the averages of each end these results may be summarized as follows:

	Total yield per acre of market-able size.	Proportion of these af-fected by rot Nov. 22.	Total yield of sound marketable tubers.	Total loss from blight and rot, con-sidering 183 bushels as the full yield.
	Bushels.	Bushels.	Bushels.	Bushels.
North end sprayed twice	183	17¾ (9.7%)	165¼	17¾ (9.7%)
South end sprayed once	173¼	18¼ (10.5%)	155	28 (15.3%)
Middle not sprayed....	136¾	50¾ (37.3%)	86	97 (53.0%)

†For more detailed description of the plot see Bulletin No. 26 pages 22-4.

Variety.	North End, Sprayed Twice.						Middle. Untreated.						South End, Sprayed Once.					
	Number of Hills Saved.	Weight of Tubers of Marketable size from same.	Rotting Tubers Among These.		Corresponding Yield Per Acre.	Corresponding Amount of Rot Per Acre.	Number of Hills Saved.	Weight of Tubers of Marketable Size from same.	Rotting Tubers Among These.		Corresponding Yield Per Acre.	Corresponding Amount of Rot Per Acre.	No of Hills Saved.	Weight of Tubers of Marketable Size from same.	Rotting Tubers Among These.		Corresponding Yield Per Acre.	Correrponding Amount of Rot Per Acre.
		lbs.	lbs.	%	bu.	bu.		lbs.	lbs.	%	bu.	bu.		lbs.	lbs.	%	bu.	bu.
Houlton Hebron							20	$7\frac{3}{4}$	$3\frac{1}{4}$	42	$93\frac{3}{4}$	$39\frac{1}{3}$	18	$12\frac{5}{16}$	$\frac{5}{10}$	$2\frac{6}{10}$	$160\frac{1}{2}$	$4\frac{3}{8}$
Rural N. Y. No. 2	26	$18\frac{1}{2}$	$1\frac{9}{16}$	$7\frac{8}{10}$	172	$14\frac{1}{2}$	40	$21\frac{1}{2}$	8	37	130	$48\frac{1}{2}$						
Early Mayflower	50	$30\frac{3}{8}$	$4\frac{3}{8}$	$14\frac{4}{10}$	147	$21\frac{1}{5}$	60	$33\frac{1}{2}$	23	$68\frac{7}{10}$	135	$92\frac{3}{4}$	20	14	5	$34\frac{8}{10}$	174	$60\frac{3}{4}$
Early King	50	$46\frac{3}{4}$	6	$12\frac{8}{10}$	$226\frac{1}{8}$	29	60	42	23	$34\frac{7}{10}$	$169\frac{1}{2}$	$92\frac{3}{4}$	38	$30\frac{1}{2}$	4	$13\frac{1}{10}$	194	$25\frac{1}{4}$
Ben. Harrison	18	$16\frac{1}{4}$	$1\frac{1}{4}$	$7\frac{7}{10}$	218	$16\frac{4}{5}$	60	$41\frac{1}{4}$	16	$38\frac{8}{10}$	$166\frac{1}{3}$	$64\frac{1}{2}$						
Snow Queen	40	$31\frac{1}{2}$	4	13	$190\frac{1}{2}$	$24\frac{3}{4}$	60	32	17	53	129	$68\frac{1}{2}$	42	$30\frac{1}{4}$	$3\frac{1}{4}$	$10\frac{7}{10}$	$174\frac{1}{5}$	$18\frac{3}{4}$
Hampden Beauty	20	$10\frac{3}{4}$	$1\frac{3}{4}$	$16\frac{33}{10}$	130	$21\frac{1}{5}$	56	$32\frac{1}{2}$	10	$30\frac{8}{10}$	$140\frac{1}{2}$	$43\frac{1}{4}$						
Beauty of Hebron	18	$9\frac{1}{2}$	0		$127\frac{7}{10}$	0	60	30	5	$16\frac{7}{10}$	121	$20\frac{1}{5}$	20	$15\frac{1}{4}$	$1\frac{1}{4}$	$8\frac{2}{10}$	$184\frac{1}{2}$	15
Burbank's Sport							44	$24\frac{3}{4}$	$2\frac{1}{4}$	9	136	$12\frac{1}{8}$	24	22	0	0	222	0
White Star							40	24	$4\frac{1}{8}$	$17\frac{2}{10}$	145	25	24	$16\frac{1}{2}$	0	0	$166\frac{4}{10}$	0

LIABILITY OF DIFFERENT VARIETIES OF POTATO TO ROT.

This is a question of considerable interest and of practical importance. There is no doubt that certain varieties of potatoes are much more susceptible to rot than others. Late varieties rot much worse than early ones, and certain of the late varieties rot worse than others. Certain of the varieties below had no rotten tubers. This should not be taken as an indication that these varities are "rot-proof," however. The amount of rot may depend so much upon other things than variety—*e. g.*, soil, drainage, depth of tubers, possibilities of infection at time of digging, etc.—that the results of a single year should be taken as suggestive rather than conclusive. The Horticulturist has kindly furnished a list of fifty of the better known varieties of potatoes which were grown at the Experiment Farm last year together with the per cent of rot in them. This list is given below. These were all grown on clay soil and sprayed four times with Bordeaux Mixture and Paris Green. The potatoes were dug and stored in October, and examinations for rot were made the latter part of December.

Variety.	Per Cent of Rotten Tubers.	Variety.	Per Cent of Rotten Tubers.
1 Advance	1.57	24 Hampden's Beauty	16.66
2 Alexander's Prolific	3.60	25 Home Comfort	5 26
3 Beauty of Hebron	7.84	26 Junkis	2.79
4 Ben Harrison	4.17	27 Late Beauty of Hebron	6.22
5 Bliss' Triumph	0.00	28 Lee's Fovorite	12.04
6 Boston Market	2.18	29 Monroe Co. Prize	9.42
7 Brownell's Best	1.28	30 New Rose	1.46
8 " No. 55	0.74	31 Northern Queen	3.39
9 " Superior	1.18	32 Pecan	8.60
10 " Winner	4.67	33 Polaris	3.72
11 Burbank's Seedling	0.00	34 Putnam's Beauty	11.19
12 Burpee's Superior	5.04	35 " New Rose	18.62
13 Chas. Downing	1.43	36 Rural Blush	3.55
14 Clark's No. 1	6.25	37 Rural N. Y. No. 2	0.00
15 Dictator	0.99	38 Seneca Red Jacket	8.43
16 Early Essex	15.92	39 Snowflake	1.54
17 " Green Mt.	0.77	40 Stray Beauty	9.73
18 " King	9.23	41 Thorburn	1.60
19 " Mayflower	2.69	42 Vermont Champion	3.31
20 " Oxford	18.88	43 White Beauty of Hebron	1.00
21 " Rose	1.88	44 " Elephant	11.56
22 " Washington	2.37	45 " Star	2.88
23 Extra Early Vermont	5.08		

Mr. C. C. Haynes of Wilmington, Vt., conducted a test of varieties under the direction of the Horticulturist. Mr. Haynes tested twenty-four varieties; the soil was very uniform, a clay loam; planted June 9th, dug Sept. 14th. The tubers were then well dried and placed on shelves until March 1st, 1891. when, at our request, Mr. Haynes made a careful examination of them * and reported as follows:

Variety.	Per Cent of Rotten Tubers.		Variety.	Per Cent of Rotten Tubers.	
	Large	Small		Large	Small
1 Burbank's Sport	13	29	13 Nathan Rose	65	70
2 Chicago Sun	24	50	14 N. Y. Plush	9	—
3 Daisy	6	31	15 Orange Co. White	17	23
4 Danby	24	46	16 Parker & Wood	23	29
5 Early Gem	54	57	17 Putnam's Beauty	52	39
6 " Goodrich	48	32	18 Randall's Beauty	14	
7 " King	57	55	19 Rose's New Giant	29	50
8 " Rose	51	—	20 B'rpee's S'dl'g, No. 37	23	47
9 Garrison's No. 8	13	21	21 Victory	50	20
10 Houlton Hebron	40	—	22 White Bermuda	66	48
11 Irish Champion	52	36	23 " Flower	15	15
12 Magnum Bonum	2		24 " Seedling	25	40

DISINFECTION OF SEED POTATOES.

Since the only way that the fungus of potato rot (*Phytophthora infestans*) is known to live through the winter is in the tubers which contain the mycelium, it would obviously be a great boon if seed potatoes could be treated in some way so as to kill this mycelium whenever present without injuring the value of the tubers for seed.

Two methods of treatment have been proposed. First, to soak the tubers in a solution of copper sulphate. Second, to heat them.

An attempt was made last summer to determine the value of these treatments. Tubers badly affected with dry rot were selected. Each tuber was cut in two lengthwise, so as to give each half an equal number of promising eyes, and one half of each was treated and the other half untreated as follows:

* In Mr. Haynes' report the sound and rotten tubers were counted, in our own examinations they were weighed. His results show therefore the relative numbers of rotten, ours show the relative weights of rotten.

First Set. Soaked 24 hours in solution of copper sulphate. (One part of copper sulphate to one hundred and five of water.)*

Second Set. Untreated halves of first.

Third Set. † Heated six hours in sealed jars immersed in water at temperature 106°–108° F.

Fourth Set. Untreated halves of third.

Some from each set were planted in each of four green-houses, and the remainder in the opposite corners of a forty-acre field, and at least sixty rods from any other potato field. Not one of those soaked in the copper sulphate solution grew.

Of the other three sets all grew. The ones in the green houses were drawn up to spindling stems and did not at any time appear healthy. The plants of the second and third sets died about August fifteenth, and of the fourth set about September fifteenth. The ones planted in the field grew with no differences that could not be attributed to differences in soil. Some leaves on all three plots showed black spots from the first of August until they were killed by the frost, but no fruiting fungus was found upon any of them. The tubers were dug the first of October and stored in the regular potato cellar. When examined March 13th they were all apparently sound. The soil was a pretty stiff clay. The probable explanation of the fact that blight did not appear more noticeably, is that the plants were in single rows and not very close together in the row, nor very leafy, hence there was little chance for that retention of moisture so necessary to the development of the fungus.

The experiment showed pretty conclusively that the copper sulphate solution can not be used of that strength and for that length of time, and seems to indicate that it probably cannot be used at all. The results as to the value of heating the tubers show that the heating did not noticeably injure the germinating power of the tuber. As to its disinfecting effects we do not feel justified in drawing conclusions..

SMUT ON OATS.

By actual count it was found that the smutted oat plants in the various fields and experimental plots in 1890 ranged from a fraction of one per cent up to *twenty-three per cent*, and that the average in all plots was about *ten per cent*. From this and similar examinations made at other stations, we think that *the average loss from oat smut throughout the State reaches nearly ten per cent of the total crop each year.*

*F. L. Scribner in Tennessee, Bul. Vol. II, No. 2, says: "It is said that tubers may be disinfected by soaking twenty-four in a solution of sulphate of copper, four to six ounces of sulphate in water enough to cover a bushel of potatoes." We weighed this amount of water and found that it was about forty pounds, (630 ounces). Six ounces sulphate in 630 ounces water, equals 1:105.

†Heating the tubers for the purpose of disinfecting them was first recommended we believe by Mr. Jensen of Copenhagen, several years ago.

In Bulletin No. 9 several remedies for oat smut were recommended.* It has been proved that these will prevent most if not all of the smut, but we have reason to fear that some of them, notably the copper sulphate solution, will injure the value of the oats for seed.

We wish that those farmers of the State, especially interested in oat raising, would examine their oat fields more carefully than usual this summer and try to satisfy themselves as to the amount of their loss from this disease,† meanwhile the Station will test the efficacy of certain proposed remedies and report upon them later.

A NEW (?) OAT DISEASE.

According to reports from various sections of the State, the young oat plants suffered seriously during the spring and early summer of 1890 from "rust." These reports stated that it was the common "red rust" of oats. No specimens were sent to the Station.

Later observations and reports lead us to believe that the disease was not the common rust which is caused by the fungus *Puccinia graminis*, but due to some other cause, possibly to the very different fungus, *Fusicladium destruens*, described by C. H. Peck, N. Y. State Botanist, as observed for the first time last year in St. Lawrence county, N. Y.‡

APPLE RUST AND CEDER APPLES.

Mr. John E. Smith of South Burlington, reported to the Station that his apple orchard suffered seriously in 1889, and in previous years, from some rust which caused the leaves to fall during the summer. His apple crop had been seriously injured for several years by this rust. Upon visiting his orchard we found that a number of red cedar trees were growing in and about the place. The branches of these red cedar trees were covered with "cedar apples." Here was the explanation of the trouble. These cedar apples are a fungous growth and strange as it seems, the same fungi which cause these "cedar apples" also attack the apple leaves and cause the "rust" on them.§

* These were:
First. Soak seed 40 hours in solution of 1 pound of copper sulphate in 4 gallons water.
Second. Soak seed 24 hours in solution of 1 pound caustic potash in 6 gallons water.
Third. Soak seed 24 hours in solution castile soap in water with enough quick lime added to color the liquid milky white.
Fourth, Soak several hours in brine strong enough to float an egg.

† The easiest and most satisfactory way to do this is to cut all the plants from a small area, say a few square feet, then sort out the smutted plants carefully and count healthy and smutted.
To get a fair idea of a field it is generally necessary to examine several such samples from different portions of the field.

‡ See 43d Report of N. Y. Museum of Nat. History, page 76.

§ A description of the fungus with plates showing the appearance of rusted apple leaves and of the "cedar apples," will be found in the Report of Department of Agriculture for 1888, p. 378, and accompanying plates XI and XII.

Since the spores from the "cedar apples" cause the rust on the apple leaves, the quickest and surest remedy is manifestly to grub out and burn the red cedars. Mr. Smith consented, however, to an experiment to test the effects of spraying the apple trees with ammoniacal copper carbonate.*

On May 17th one of the apple trees was sprayed thoroughly. The limbs of this tree mingled on one side with those of an infected red cedar, and the apple tree had been the worst rusted of any in the orchard in 1889. At the time of spraying, the apple leaves were about half size and the flower buds swollen. Only a few of the cedar apples had sent out their characteristic jelly-like protrusions. A week later the tree was examined and it was found that some injury to foliage had been caused by the solution, many leaves being spotted. On May 30th this tree was again sprayed, the solution being diluted by adding one-half more water than before. Another tree was also sprayed.

July 2d the leaves were examined on a typical branch of the first tree sprayed and of another adjacent tree which had not been treated. The results were:

Healthy leaves on tree sprayed	215	25%
Rusted " " " "	645	75%
Total	860	100%
Healthy leaves on tree not sprayed	450	23%
Rusted " " " " "	1541	77%
	1991	100%

This shows no marked difference in the number of affected leaves, although the real benefit of the spraying in this respect was greater than the above figures indicate because the sprayed tree had been in previous years attacked considerably the worse of the two. The rust was not so abundant on the individual leaves of the sprayed tree, although about as many leaves were attacked on the sprayed tree as on the unsprayed.

The benefits of the spraying did show very decidedly in the general appearance of the trees. This was still more evident in August. The leaves of the unsprayed tree had then nearly all fallen and the remaining leaves were small and badly rusted, while the apples were few, small and of no value.

The sprayed tree was far from healthy looking but it had kept most of its leaves and was ripening a fair crop of fruit. No good apples were gotten from the unsprayed tree; from the sprayed about two barrels were gotten. The tree sprayed May 30th was helped some but not nearly so much.

* One ounce copper carbonate dissolved in one quart ammonia then diluted with water to twenty-five gallons.

ONION SMUT.

In 1889 serious trouble from "smut" and "blight" was reported by onion-growers about Burlington, and more especially from Grand Isle. This disease was doubtless due to a fungus, but as no botanist was then connected with the Experiment Station and as no specimens or exact information as to the nature of the disease have been procurable since our connection with the Station, we cannot say with certainty which of the several fungus enemies of the onion caused the disease. It was planned to study this disease and its possible remedies last summer, but only a small per cent of the seed sown in our experimental plot germinated. As no reports of smut were received from onion growers, we conclude that little or no loss was experienced in 1890 from the disease.

We hope that onion growers who are troubled will let us know promptly upon any serious outbreak of the disease this summer, and send us specimens of the diseased plants, that we may learn more about the disease and help to control it if possible.

BLACK KNOT OF PLUM AND CHERRY.

Black knot is prevalent and troublesome about Burlington on both plum and cherry trees, and reports have come to us from various parts of the State of its general prevalence. Indeed it seems to have practically exterminated these trees in many orchards of the State. The disease is too well known to require description. It does not seem to be generally appreciated, however, that black knot is caused by a fungus, and that from the knots of one tree, millions of spores are annually discharged to infect other trees in the same or adjoining orchards. When this fact is appreciated the remedy will scarcely need to be emphasized. *Cut down and burn every badly affected tree and thoroughly prune out the affected limbs of those not so badly attacked, AND SEE THAT YOUR NEIGHBORS DO THE SAME.*

As the fungus flourishes on most species of wild plums and cherries it will be necessary to watch these trees as well as the cultivated ones.

It is evident that by united action a fungus which is so conspicuous and so slow in its development as this can soon be controlled, or even exterminated, if a united fight is made against it. To assist in and insure such work we need a State law operating against these contagious diseases of plants just as we now have laws operating against similar contagious diseases of animals. It is believed that a law which will have this end in view can be framed and presented to the next legislature, and if so, it ought to have, and we trust will have, the earnest support of every farmer and fruit grower of the State.

NOTES UPON SOME OTHER FUNGOUS DISEASES WHICH ARE PREVALENT.

BLACK SCAB OF APPLE.—This is caused by the fungus *Fusicladium dendriticum.* The spores are produced in olive green patches upon the fruit and leaves, and even upon the younger branches of the trees. We found a luxurious growth of the fungus producing myriads of spores upon Greenings several weeks after they were stored in our cellar last fall. It is possible that conditions may be such that these spores may germinate and spread the disease to the uninfected fruit after storing. If so, this may explain in part the spotting of the apples after they are barrelled.

Experiments at the Wisconsin and Michigan Stations in 1889 showed that by proper spraying much of the injury from the scab fungus can be prevented.

Mr. Goff of the Wisconsin Station, recommends as the results of his experiments the following treatment: "Dissolve one ounce of copper carbonate in one quart ammonia (strength of 22° Baume). Keep corked tightly until ready for use, then dilute with 25 gallons of water. Spray once just before the flowers open, a second time just after the petals fall and repeat at intervals of two or three weeks until midsummer. Wait a few hours after spraying with this before spraying with Paris green for the codling moth."

BLACK SCAB OF PEAR. This is especially troublesome on Flemish Beauty Pears. It is caused by a fungus growth, in the same way that apple scab is, and can doubtless be checked in the same way.

PEAR BLIGHT, *Fire B light*, occurs everywhere about the State, and needs no description from us. It is caused by the action of bacteria (*Micrococcus amylovorus*). The only remedy known is to cut off the smaller limbs a foot or two below the lowest manifestation of the disease, and to shave out the spots where the disease appears on the trunk, cutting deeply enough to remove all discolored tissue. A good precaution is to disinfect the knife after cutting through a diseased spot by dipping in carbolic acid.

The same blight attacks apple trees, though not so commonly as it does the pear. An outbreak of what was probably apple blight was reported to us from the southern part of the State. The same treatment is recommended as for pear blight.

STRAWBERRY LEAF-BLIGHT.—The spotting of strawberry leaves is another disease familiar to every one. The disease appears on the leaves as small reddish or purplish spots, which increase in size and change in color, until finally they are from one-sixth to one-third of an inch in diameter, and have a grayish white center, surrounded by a purple border which shades off into a reddish brown at the outer edges.

Remedy.—The disease causes most injury by attacking the new growth of plants which spring up first after the berries have ripened. This injury can be much lessened by in some way destroying the old infected leaves as soon as the berries are picked. This can be readily done by mowing the leaves close to the ground, and burning them as soon as they have dried enough. Another way of accomplishing the same object recommended in the Report of the Department of Agriculture for 1889 is to spray the plants with a solution consisting of one pint of sulphuric acid to six gallons of water. For the ordinary gardener the method of burning will be found preferable, however.

Several other fungus diseases occurred about Burlington to a serious extent last summer, which were harder to control. Among these was *Clover Rust*, occurring as small brownish red spots on the leaves of clover. It is caused by the fungus *Uromyces Trifolii*. In one field examined in October it was hard to find a leaf that was not attacked by this fungus. It is difficult to estimate just how great was the damage from this rust, but it is certainly a serious disease and may well be watched.

The *Currant Rust* or *Leaf Spot Disease*, caused by the fungus *Septoria Ribis* was very injurious upon the currant bushes at the Experiment Farm last summer. It shows as whitish spots with dark centers through the middle and latter part of the summer. The leaves began to fall early and the bushes were nearly naked by the middle of September.

The *Cane Rust* was very injurious to Black and Red Raspberries and to Blackberries. This is a disease which has been observed but little until the last few years, but which threatens to be very injurious. It is caused by the fungus *Gleosporium necator*. The disease appears first on the young canes as small purplish spots. These enlarge and the centers change to a dirty white. On the older canes the spots often merge together and nearly cover the surface of the canes. The disease appears similarly on all parts of the leaves.

Ergot was very abundant on rye. This is caused by the fungus *Claviceps purpurea*. It forms the conspicuous black "spurs" on the head which are often three-quarters of an inch in length. A small field of spring wheat near the Station was also badly ergoted. The spurs on the wheat were smaller and thicker, differing in shape from the spurs on the rye, in about the same way that the kernels of the two grains differ.

It was found very abundantly on various species of native grasses also.

The loss of grain or grass from ergot is usually comparatively slight, but where it occurs very abundantly it is injurious to the stock eating it, often causing abortion.

The grape mildews, the Downy mildew caused by the fungus *Peronospera viticola*, and the Powdery mildew caused by *Uncinula spiralis* wer

both observed at various points about the State, and did considerable damage in some cases reported to us. As most grape growers know, these diseases can be controlled by the use of the Bordeaux Mixture as recommended for the potato rot. If any one wishes further information concerning these diseases or their remedies we shall be glad to answer any letters of inquiry.

The Powdery Mildew of the cherry caused by the fungus *Podosphaera oxycantheae* was found doing some damage upon a few young cherry trees. It was observed too late in the season to check it, as could doubtless have been done by spraying earlier.

Hollyhock Rust caused by the fungus *Puccinia Malvacearum* was found in several places in and about Burlington. This disease appears as small wart-like swellings on the lower side of the leaves of hollyhocks, and when these become numerous the leaf may die.

These swellings vary in color from a grayish-brown to a dark-brown. In size they vary from a small dot to the size of a pin-head or larger.

This fungus is of a peculiar interest, since it was introduced into this country only a comparatively few years ago from South America, and is gradually spreading.

We collected last summer plants showing specimens of the diseases spoken of in this report. We shall be glad to distribute these as long as our supply lasts to persons in the State who are interested in these diseases and who will write for them, stating what ones they wish.

We are grateful for information concerning any unusual occurrence of any plant disease. Always send specimens of the diseased plants when you can. Any letters of inquiry concerning plant diseases or remedies for the same will be promptly answered.

they took six quarts a day, after which the amount of skimmilk remained constant at this quantity, and the rest of the ration was made up of constantly increasing quantities of grain. The trials as a whole have shown that skimmilk can be profitably used for pig feeding or rather that pigs can be grown with profit where there is skimmilk to serve as part of the ration. In all of our work the attempt has been not to see how large a number of pounds of pork could be grown in a given time, but to see with how little food it is possible to grow a pound of first class pork. In this particular line we have been eminently successful. The first year requiring 2.79 pounds of dry matter in food to one pound of gain in live weight. The second year 2.92, and the third 2.82 an average for the whole, of **2.84.** The best results were obtained on one pig in 1889, which consumed but 2.40 pounds of dry matter for each pound of gain in live weight. The poorest results were obtained in 1890 when two pigs each required 3.20 pounds of dry matter to each pound of gain in live weight.

A study of the rations ordinarily fed on the farm, and the results obtained leads to the conclusion that in the best of farm practice a pound of gain in live weight is seldom obtained with less than 3¼ to 3½ pounds dry matter in the food. With corn meal, gluten meal, and middlings at $26 a ton and bran at $24, all of these prices being exceptionally high, and with the pork selling at 5 cents a pound live weight, and with skimmilk at 15 cents per hundred pounds, the food to produce a pound of live weight, has cost on the average **4.19** cents, and has returned a gain of 19 per cent over cost of feed. If from the selling price we subtract the amount paid out for grain and consider the balance as what we have received for the skimmilk, we find the amounts varying in the different experiments from 24 to 27 cents, an average of **25** cents per hundred pounds. In addition to this we find that there has been returned in the fertilizing value of the food just about two-thirds of the cost of the food, so that if we consider the fertilizing value as offsetting the labor, there has been returned a large value for this labor.

REPORT OF THE BOTANIST.

L. R. JONES.

Fungous diseases of plants and their remedies have again been made the principal subjects of investigation in this department.

It is now proved beyond question that some of our worst plant diseases can be economically checked, if not prevented, by the intelligent use of fungicides, and we hope that the value of the copper compounds as remedies for potato blight and similar diseases, will soon be as well understood as is the value of Paris green in destroying the insect enemies of our crops. While the general practicability of spraying to check potato blight and other fungous diseases of plants, is then no longer a subject for experimental research there are many practical questions of immediate importance concerning the best times and methods of applying these remedies as well as the question as to what is the best kind and strength of remedies to use in each case.

Since this report could not be distributed early in the season, the most practical results of the work have been prepared for publication in bulletin form*. It being undesirable to duplicate such matter in detail, only brief mention is here made of the subjects treated in this bulletin, and the bulletin itself may be considered in a measure as a part of this report.

Following is a list of the subjects discussed in this report :

I. Spraying with Bordeaux Mixture for the Potato Blight and Rot.

II. A Comparative Test of Several Fungicides for Potato Blight.

III. A New Potato Disease.

IV. The Prevention of Apple and Pear Scab by Spraying.

V. Apple-rust and Cedar-apples.

VI. A Spot Disease of Baldwin Apples.

VII. The Brown-rot of the Plum.

VIII. Oat Smut.

(*a*) The Prevention of Oat Smut.

(*b*) The Amount of Loss from Smut in Oats.

(*c*) Will it pay to Disenfect Seed Oats.

IX. Effects of Various Fungicidal Treatments upon the Vitality of Seed Corn.

X. Lettuce Mildew and Lettuce Rot.

XI. Vermont Weeds.

*Bulletin 28.

I. SPRAYING WITH BORDEAUX MIXTURE FOR THE POTATO BLIGHT AND ROT.

The nature and value of this remedy has been so fully discussed in our former publications that only brief mention of the results of the work of the past year will be made here.

The experiments at Burlington were cut short by the ravages of the new disease mentioned later in this report. Work was also carried on at the farm of J. E. White in Shelburne, O. E. Stone, Charlotte and Moses H. Kelsey, Salisbury. The results of this work are discussed so fully in Bulletin 28, that only the following tabulated statement is here given.

		Yield where Sprayed.	Yield where not Sprayed.	Gain in bu.	Per cent gain.
J. E. White's..	Sprayed Aug. 20-Sep. 8.	313 bu. per A.	248	65	26
O. E. Stone's..	" July 3, 23, Aug. 18.	206½ "	168	38½	23
M. H. Kelsey's	" July 20.	*	*		

In addition to the above gratifying results, letters were received from several potato growers who used the Mixture with good success. The most noteworthy facts aside from the above, brought out in these trials, were :

First : When a liberal application was made after the blight appeared but before it spread very badly, it was fairly well held in check.

Second : Where the treatment was successfully begun and continued up to Aug. 20, and then discontinued the disease reappeared and did considerable harm during September.

Third : The gain from increased yield due to prolonged life of the vines may exceed the gain from prevention of rot, as stated in Bul. 28 : "Providing we can by spraying keep the tops alive three or four weeks longer in the fall, we may increase the yield over 25 per cent, to say nothing about the prevention of rot or improvement of the quality of the tubers due to thorough ripening."

*One piece not sprayed, yielded 180 bu. of which 80 bu. rotted. Another piece that was sprayed, yielded 300 bu. of which less than one bushel rotted. Mr. Kelsey attributed the difference in the amount of rot to the use of the Mixture. The difference in yield was largely due to other causes.

II. A COMPARATIVE TEST OF FUNGICIDES FOR POTATO BLIGHT.

The value of Bordeaux mixture in checking potato-blight is settled beyond question. This fungicide however as ordinarily used is open to two serious objections. First, it is the most expensive of the standard fungicides; and second, the copper salt being insoluble forms a "sediment" which necessitates the constant stirring of the mixture during use and causes considerable trouble by clogging the nozzles of the spraying pump. These objections have suggested to all using the mixture, the desirability of some substitute or modification.

It seems hardly probable that any soluble fungicide can resist the washing of dew and rain so long as the insoluble Bordeaux mixture. The more hopeful outlook for improvement is therefore along the line of a more dilute form of the Bordeaux mixture. We made a comparative test of four fungicides upon potatoes this year. They were stronger Bordeaux mixture (6 lbs. copper sulphate, 4 lbs. lime, 22 gals. water); weaker Bordeaux mixture (6 lbs. copper sulphate, 4 lbs. lime, 33 gals. water), ammoniacal copper carbonate (5 oz. copper carbonate, 3 pints ammonia, 45 gals. water,) and glue mixture * (12 oz. sodium carbonate, 10 oz. copper sulphate, 8 oz. liquid glue, 45 gals. water.) The fungicides were applied to plots in five different potato fields. In two of these fields the "new disease" killed the vines before any of the true blight (*Phytophthora infestans*) appeared. In two others the injury to the vines sprayed with the ammoniacal copper carbonate, and also those sprayed with the glue mixture was quite marked within a few days after the first application—so much so, indeed, that the owners of the fields who had undertaken to make the test asked permission to discontinue the use of these fungicides. Another field of potatoes sprayed very liberally with these same fungicides showed not the slightest signs of injury from any of them even after three applications were made. In order to test the matter more fully the fungicides were applied on this latter field at the rate of about 25 gallons per acre, when the second application was made July 28, yet no signs of injury were seen. Possibly the variety of potato had something to do with it. The varieties showing injury were Garfields and Early Rose. The variety showing no injury was White Star.

Only one of these experiments was therefore carried through to the end of the season. That was upon a piece of late potatoes, White Stars, at Mr. J. E. White's of Shelburne. No applications were made until the disease appeared August 26, when blighting leaves were found on nearly every hill. Plots were then sprayed with each of the four fungicides under trial. Sept. 5, there was a marked difference in the various treated

*Recommended by B. T. Galloway.

and untreated plots, showing no benefit from the use of the ammoniacal copper carbonate, a very slight benefit from use of the glue mixture, more marked benefit where the Bordeaux mixture one-half strength was used, and very great benefit where the full strength Bordeaux mixture was used. September 8th when the second application of the fungicides was made the plots sprayed with the glue mixture and ammonical copper carbonate, were so badly diseased that the treatment was discontinued, nearly every leaf on the latter and more than half on the former being dead, and the remainder all dying. The applications of the two strengths of Bordeaux mixture were repeated. The potatoes were dug September 23, the workmen, not understanding directions made measurements of only the ones treated with Bordeaux mixture full strength and the adjoining untreated plots. The yields as reported in Bulletin 28 were at the rate of 313 bu. marketable tubers per acre where sprayed, and 248 where not sprayed, a gain of 65 bu. per acre or 26 per cent. These result would indicate therefore that both the glue mixture and the ammoniacal copper carbonate are liable to injure the potato leaves and were not at all equal to the Bordeaux mixture in efficiency; that the weaker Bordeaux mixture was not so good as the full strength mixture at least where the disease is well started. Had the experiments upon some of the plots where the applications were begun earlier been carried through to the close of the season the weaker fungicides would probably have given better results than they did in this case.

III. A NEW POTATO DISEASE.

A potato disease closely resembling the blight in its effects but entirely different in its real nature has been noted in our fields the past two years. This year the disease appeared very generally in the potato fields of the State. The appearance and probable bacterial nature of the disease are discussed in Bulletin 28.

The possibility of checking the spread of this disease by proper use of Bordeaux mixture is one of much practical interest. Dr. Halsted of the New Jersey Experiment Station, states that Bordeaux mixture has proved effective against the bacterial disease of the potato* and recommends its use. In our experience last summer the benefit from the use of Bordeaux mixture with this disease was very slight if there was any at all. The new disease spread over plots sprayed with Bordeaux mixture, with ammoniacal copper carbonate, and with glue mixture and did this in two different fields and at different times in the season. The first field was sprayed June 29th and 30th. The new disease was then just beginning to show and continued to spread over sprayed as well as unsprayed plots and

* Miss. Bul. 19, p. 12.

fields all through July. By the middle of August all vines were dead. Another field of later potatoes was sprayed much more thoroughly. Liberal applications of each of the three fungicides were made to plots on July 9, July 28 and August 10. The disease had made considerable headway by the last date and plots sprayed with Bordeaux mixture were somewhat darker green and thriftier than the untreated plots on either side.* Ten days later the disease had killed the leaves upon nearly half the plants of the field.

Very careful examination was made to determine the relative amount of the disease upon the various plots. The results showed very little if any difference in favor of the sprayed plots. By September 1, most of the leaves upon all plots were dead. October 3 the potatoes were dug. The yields were as follows:

Plot 1, untreated, 159 bushels per acre.

Plot 2, Bordeaux mixture full strength, 160 bushels per acre.

Plot 3, Bordeaux mixture $\frac{2}{3}$ strength, 242 bushels per acre.

Plot 4, untreated, 181 bushels per acre.

These variations in yield agree closely with varying amounts of disease on these plots as shown by the notes taken August 20, hence it seems fair to infer that the difference in yield was due to the difference in disease, and this difference seems to bear no direct relation to the treatment. †

IV. THE PREVENTION OF APPLE AND PEAR SCAB BY SPRAYING.

The work along this line also is fully discussed in Bulletin 28, so that only a brief statement of the results is here given.

Ammoniacal copper carbonate, Bordeaux mixture and Solution No. 5 of the U. S. Dept. of Agriculture were used in the work upon the apple trees (Greenings), and ammoniacal copper carbonate upon the pear (a young Flemish Beauty tree). The pear was sprayed seven times, beginning May 19, just as the blossoms were opening, and repeated at intervals of about two weeks until August 8th.

The work upon the apple trees was also begun just before their blossoms opened. In most cases only four applications were made, the last

*Since writing the above, Bul. 15 of the Delaware Station has been received. Prof. Chester in speaking of what appears to be this same disease says: "It has been claimed that the trouble can be held in check with the Bordeaux mixture, applied as directed in the former disease [potato blight]. This, however, was not the case in an experiment conducted by the writer in which several potato plots were sprayed thoroughly throughout the season with Bordeaux mixture, but in spite of heavy applications the plants went down completely before the tubers were the size of walnuts."

†This difference was hardly more than we have often noticed in favor of the sprayed vines when there has been no indication of any diseased condition, we have thought that it might be due to fertilizing action of the sulphate of lime (gypsum) contained in the Bordeaux mixture. Much the same stimulating result is often seen when gypsum mixed with Paris green is dusted upon the vines.

being July 17th. Seven applications of the ammoniacal copper carbonate were made upon two of the apple trees, as upon the pear, but with only slightly increased benefits. The Solution No. 5 was used upon two trees, one Greening and one Fameuse, but injured the leaves so badly that its use was discontinued.

The results of the spraying briefly summarized are :

	Smooth Fruit.	Scabbed Fruit.
Flemish Beauty Pear—Sprayed tree	69%	31%
" " " Check tree not sprayed	28%	72%
Greening Apples :		
Ammoniacal Copper Carbonate, average of 5 trees	63%	37%
Bordeaux Mixture, average of 6 trees	74%	26%
Check trees, not sprayed, average of 9 trees	12%	88%

V. APPLE RUST AND CEDAR APPLES.

In our last annual report* mention was made of an attempt to control the rust upon apple leaves by spraying with ammoniacal copper carbonate. This rust is another stage of the fungus which causes the common "cedar apples" of red cedars. It is probable that the easiest way to get rid of the trouble is, therefore, to destroy the cedars themselves. It seemed desirable, as a matter of scientific interest, to try another year the efficacy of spraying before destroying the cedars.

Accordingly the same apple tree sprayed last season was again selected for the experiment. It was sprayed May 14. The cedar apples had begun to burst their coats at this time, but no gelatinous tongues were protruded. May 23 and June 15 a second and a third application were made. As a result of these applications the rust did not injure the foliage on this tree nearly so badly as on unsprayed trees, but, nevertheless, nearly every leaf had more or less of the rust upon it. The branches of a cedar tree on one side intermingled with those of the apple, and as this was loaded with "cedar apples" the possibilities of infection were very great. Still the results as tested last year would seem to show that spraying with ammonical copper carbonate does not offer a satisfactory protection against the rust so long as the red cedars are tolerated. It is now planned to remove the infested red cedars in or near the orchard and watch the effect another year.

VI. A SPOT-DISEASE OF THE BALDWIN APPLE.

While examining orchards in the fall it was noticed that many of the Baldwin apples showed sunken brown spots of the size of a pea or larger.

*4th Rep. Vt. Exp. Sta., 1890, p. 139.

The flesh underneath the spot showed brown discoloration for an eighth of an inch or more in depth, and this discolored portion was quite bitter to the taste. Specimens of the diseased apples placed in a moist chamber soon developed small grayish pustules at or near the center of the spot, the pustule being from a sixteenth to an eighth of an inch in diameter. Microscopic examination of these pustules showed their fungous nature, and their general occurrence upon the center of the brown spots indicated a direct causal connection of the fungus with the spot.

Mr. J. B. Ellis of Newfield, N. J., identified the fungus as being probably *Dothidea pomigena*, Schu. Owing to lack of material a satisfactory study of the structure of the fungus was not completed. Inquiry among orchardists indicates that the disease is quite common upon Baldwin apples throughout the State. Its occurrence upon other varieties was not noted. Further study of the disease will be made another year.

VII. THE BROWN ROT OF PLUMS.

There was an unusually heavy crop of plums in most of the orchards of the State last year, and during the latter part of the summer the losses from the brown rot were very great. This rotting is often confused by the orchardist with the attack of the plum curculio. The rot often begins at the point where the insect punctures the fruit, but this is not necessarily the case. The disease may attack sound fruit as we satisfied ourselves by placing sound and decaying plums together under a bell glass. In a few days the disease appeared on the sound plums the germination spores having gained entrance through the unbroken skin.

The disease is caused by the attack of the fungus *Monilia fructigena*. The fungus spreads rapidly by spores which are extremely hardy. A "mummied" plum covered with these spores was brought into the laboratory in January. It was frozen solid of course and moreover completely covered with a coat of ice from a sleet that had fallen a few days before. Placed in favorable conditions in the warm room it soon thawed and a a few days later germinating spores were found. The disease is therefore capable of propagating itself from year to year in the decayed plums which remain through the winter, clinging to the trees or scattered on the ground.

The most important thing in the treatment of the disease during the summer, is therefore the prompt removal and destruction by fire or deep burial of all rotting fruit as soon as it appears. All "mummied" plums should be picked from the trees in the fall or winter, and if any have fallen to the ground they should be picked up and the ground ploughed to bury any that may be overlooked.

If the trees were badly affected the preceding year, spray the limbs

and trunks before the buds swell in the spring, with a solution of copper sulphate (blue vitrol) in water, 1 pound blue vitrol to 16 gallons of water. Beneficial results have been reported where the trees were sprayed with ammoniacal copper carbonate a few times during the summer, and where the disease is bad, this treatment is recommended in addition to the above.

VIII. OAT SMUT.

(*A*) THE PREVENTION OF OAT SMUT.

The value of soaking seed oats for a few minutes in hot water in order to disinfect from smut is discussed in Bulletin 28. Methods varying in the temperature of the water used and in the length of time of immersion are recommended by different experimenters. A comparative test of several of these was made the past summer. The two methods most generally recommended are: (1) Soaking 15 minutes in water held at a temperature of 132°-135° F., then cooling with cold water. (2) Soaking 5 minutes in water at 136°–138° and spreading out at once to dry.

Portions of the seed designed for sowing in the regular oat field of the Experiment Farm were treated in each of the above ways. The latter method proved to be the more convenient, but the former was more beneficial to the grain as shown by improved germination and healthier color of young plants. The conditions of soil were such that it was not possible to get reliable data as to the effect of the treatment upon the yield of grain. Both methods were entirely effectual in destroying the smut. The portion of the field sown with untreated seed had over 4 per cent of smutty heads (4.2 per cent) while only a single smutted head was found in the entire portion of the field where the seed had been soaked.

Smaller garden plots also were sown with Dakota gray oats which were known to be quite smutty in order to test the disinfecting power of various methods of treatment. At the time of harvesting, samples were taken from each plot and the number of healthy and of smutted heads in each determined as follows:

	Healthy.	*Smutted.*	*Per cent smutted.*
Plot 1.—Untreated seed	1010	106	10 per cent.
" 2.—Seed soaked at 130–5° F., 5 minutes	550	11	2 " "
" 3.—Seed soaked at 135–40° F., 5 minutes	334	0	0 " "
" 4.—Untreated seed	800	51	6.4 " "
" 5.—Seed soaked at 140–5° F., 5 minutes	250	0	0. " "
" 6.—Seed soaked at 130-5°F., 15 minutes then cooled in cold water	260	0	0. " "
" 7.—Untreated seed	570	49	8.6 " "

The disinfecting value of the different methods is evident at a glance. Here again conditions of drainage in the latter part of the summer prevented a just comparison of the yields of the different plots. The germination and early growth gave the following evidence as to the effects of the various treatments:

Plot 2.—Apparently a little better than untreated.

Plot 3.—About equal to the untreated, but not quite so good as No. 2.

Plot 5.—Not quite so good as the untreated.

Plot 6.—About equal to the untreated.

Judging from these experiments we recommend as the safest and best method the soaking of seed oats 15 minutes at temperature 132°-135°, then cooling with cold water.

(*B*) AMOUNT OF LOSS FROM SMUT IN OATS.

Since we have a reliable remedy for oat smut in the proper use of hot water for disinfecting the seed oats, it is a matter of most practical importance to learn just how great is the loss in our oat fields from this disease. As the smutted heads are not very conspicuous after the grain is fully headed the amount of the loss is generally underestimated.

We determined the average loss in all plots at the Experiment Farm in 1890 as about 10 per cent. The average loss about Burlington last summer was considerably less than this as indicated by the results of examinations made in ten oatfields in this vicinity. The samples were taken by placing a frame two feet square in the grain and cutting all plants included by it. The samples were taken from various parts of the field in all cases, and in order to avoid any chance for discrimination the person taking the samples would close his eyes, walk a dozen steps then place the frame over the grain before opening his eyes. This certainly did away with any personal equation.

Field I. Clydesdale oats—seed from Richard Nott, Burlington—Ten samples taken.

Total number heads, 730; smutty, 30; per cent smut, 4.2.

Field II. American Banner—seed from J. M. Vick, Rochester, N. Y.—Five samples taken.

Total number heads, 224; smutty, 0; per cent smut, 0.

Field III. White Minnesota—Four samples taken.

Total number heads, 545; smutty, 13; per cent smut, 2.4.

Field IV. Dakota Gray—home grown seed—50 samples taken.

Total number heads, 4130; smutty, 278; per cent smut, 6.4.

Field V. White Canadian Oats—seed from A. G. Peirce—Ten samples taken.

Total number, 721; smutty, 20; per cent smut, 2.8.

Field VI. Common White Oat—Five samples taken.
Total number, 437 ; smutty 14 ; per cent smut, 3.2.

Field VII. Common White Oat—Ten samples taken.
Total, 634 ; smutty, 21 ; per cent smut, 3.3.

Field VIII. White Oat, variety unknown—Ten samples taken.
Total, 1196 ; smutty, 68 ; per cent smut, 5.73.

Field IX. Common White Oat—Five samples taken.
Total, 484 ; smutty 7 ; per cent smut, 1.46.

Field X. White Oat, variety unknown—Six samples taken.
Total, 525 ; smutty 15 ; per cent smut, 2.86.

Average per cent smut in ten fields, 3.2.

(*C*) WILL IT PAY TO DISINFECT SEED OATS?

Granting that our oat crop is reduced 3 per cent to 4 per cent by the smut, is this amount large enough to pay for the trouble of disinfecting the seed? It is unquestionably a considerable trouble to soak all of our seed oats in hot water as recommended. In order to get a more definite idea of the actual expense of thus treating the seed, 20 bushels of grain were disinfected, all items of expense being noted. An old trough about two feet deep, a kerosene barrel and two wash tubs were the vesels used. The oats to be disinfected were placed in old fertilizer sacks, a bushel in each sack. The trough was large enough so that two of these sacks were immersed at a time. Working in this way it took two men four hours to disinfect 20 bushels, carry them up two flights of stairs and spread them out to dry. As the work was done in the winter it was necessary to keep this drying room heated that the oats might not freeze.

The total cost of the treatment and drying was :

16 hours work at 15 cts	$2.40
300 lbs. coal at $5.75 per ton	.87
Total cost	$3.27
Cost per bushel	.16⅛

We had one advantage in this work that should be mentioned, we were able to heat the water by steam from the boiler of the furnace in the dairy building. It would require the assistance of another man or boy to heat the water upon an ordinary cook stove and work so rapidly.

If 3 bushel of seed be used per acre the cost of disinfecting would be about 50 cents upon the basis of this work. If the yield from the same be 40 bu. of which 4 per cent or about 1½ bu. were otherwise lost because of smut the gain would barely pay for the trouble of disinfecting the seed.

There are at least two important considerations that come into the account here, however.

First—If the smut is destroyed in the seed oats this year the grain from this field will have no smut and this strain of oats can be grown for several years before it will become again seriously affected with the disease. Treating the seed one year then insures an increase of 3 or 4 per cent in each crop for a number of years.

A second and very important consideration is the possible gain aside from and beyond the destruction of the smut. The soaking of the seed in warm water appears to improve its quality in some way not as yet explained. Our fields last summer all seemed to show this. Experiments at other Stations in this country and in Europe all indicate the same fact. An increase in yield of from 5 to 10 and even more bushels per acre, is claimed as due to the beneficial effects of soaking the seed. If this is true will it not pay to soak all our seed oats in hot water for the beneficial effects of the treatment aside from any consideration of smut? Judging from a number of tests of treated seed in green house beds and germinating pans, we believe that the effects of the treatment will be found to vary with different samples of seed, and that the question needs more investigation before we make any absolute statement.

IX. THE EFFECTS OF VARIOUS FUNGICIDAL TREATMENTS UPON THE VITALITY OF SEED CORN.

The advisability of soaking seed corn in some solution to destroy smut-spores that may be clinging to it has been advocated more or less for many years. Various solutions for this purpose have been advocated, a solution of blue vitrol in water being most commonly used. Although effectually destroying smut, blue vitrol solutions have an injurious effect upon most seed grain. The hot water remedy on the other hand promises to be beneficial rather than injurious in most cases, and to be equally effectual as a fungicide against the smut. It seemed advisable to test the effects of the warm water treatment upon the germination of seed-corn. The work was begun in the greenhouse, seed being subjected to following treatments just before planting:

Row 1.—Soaked in water at 130° F 15 min. then cooled in cold water.
" 2.—Untreated.
" 3.—Soaked in water at 140° F 15 min. then cooled in cold water.
" 4.—Soaked in ½ per cent solution copper sulphate 24 hours.
" 5.—Untreated.
" 6.—Soaked in 1 per cent solution copper sulphate 24 hours.
" 7.—Soaked in 6¼ per cent solution copper sulphate 10 hours.
" 8.—Untreated.
" 9.—Soaked in 6¼ per cent solution copper sulphate 24 hours.

Conclusion: (1)—The hot water treatments (1 and 3) both injured the vitality of the seed, the injurious effects of the higher temperatures being quite marked. Of the blue vitrol treatments No. 7 did not injure the seed, all of the other treatments were injurious, Nos. 4 and 6 being somewhat and No. 9 very noticeably injured. It is worthy of note that the vitality of all the seed was low, only 90 per cent of the untreated seed growing. The same line of investigation was undertaken on a much larger scale in the field in the summer.

Two plots were planted, each containing 72 rows, 25 hills in each row. These plots were duplicates except that in plot B, King Phillip corn was used and in plot A, common 8-rowed flint corn. The latter was excellent seed the former not so good, and this fact adds additional interest to the results.

The treatments of the plots were as follows:

Row.	Treatment.		
1.	Untreated.		
2.	Soaked in water at 100°–105° F.	5	minutes.
3.	“ “ “ “	10	“
4.	“ “ “ “	15	“
5.	Untreated.		
6.	Soaked in water at 105°–110° F.	5	minutes.
7.	“ “ “ “	10	“
8.	“ “ “ “	15	“
9.	Untreated.		
10.	Soaked in water at 110°–115° F.	5	minutes.
11.	“ “ “ “	10	“
12.	“ “ “ “	15	“
13.	Untreated.		
14.	Soaked in water at 115°–120° F.	5	minutes.
15.	“ “ “ “	10	“
16.	“ “ “ “	15	“
17.	Untreated.		
18.	Soaked in water at 120°–125° F.	5	minutes.
19.	“ “ “ “	10	“
20.	“ “ “ “	15	“
21.	Untreated.		
22.	Soaked in water at 125°–130° F.	5	minutes.
23.	“ “ “ “	10	“
24.	“ “ “ “	15	“
25.	Untreated.		
26.	Soaked in water at 130°–135° F.	5	minutes.
27.	“ “ “ “	10	“
28.	“ “ “ “	15	“
29.	Untreated.		
30.	Soaked in water at 135°–140° F.	5	minutes.
31.	“ “ “ “	10	“
32.	“ “ “ “	15	“
33.	Untreated.		
34.	Soaked in water at 140°–145° F.	5	minutes.
35.	“ “ “ “	10	“
36.	“ “ “ “	15	“
37	Untreated.		

Row.	Treatment.
38	Soaked in water at 145°–150° 5 minutes.
39	" " " 10 "
40	" " " 15 "
41	Untreated.
42	Soaked in Bordeaux mixture * 5 minutes.
43	" " " 10 "
44	" " " 15 "
45	Untreated.
46	Soaked in Bordeaux mixture 1 hour.
47	" " " 6 "
48	" " " 5 minutes.
49	Untreated.
50	Soaked in double strength Bordeaux mixture 10 minutes.
51	" " " " " 15 "
52	" " " " " 1 hour.
53	Untreated.
54	Soaked in double strength Bordeaux mixture 6 hours.
55	" quadruple " " " 5 minutes.
56	" " " " " 10 "
57	Untreated.
58	Soaked in quadruple strength Bordeaux mixture 15 minutes.
59	" " " " " 1 hour.
60	" " " " " 6 "
61	Untreated.
62	Soaked in 6 per cent copper sulphate solution, —5 minutes.
63	" " " " " " 10 "
64	" " " " " " 15 "
65	Untreated.
66	Soaked in 6 per cent copper sulphate solution 1 hour.
67	" 12 " " " " 5 minutes.
68	" " " " " " 10 "
69	Untreated.
70	Soaked in 12 per cent copper sulphate solution 15 minutes.
71	" " " " " " 1 hour.
72	Untreated.

There was no smut upon any of the corn hence the fungicidal value of the various treatments was not determined.

The following are the conclusions reached as to the effects of the various treatments upon the vitality of the seed corn.

1. The King Philip corn was injured by the hot water at a lower temperature than was the 8-rowed corn. This was probably due to the lower vitality of the King Philip corn.

2. With the King Philip corn the hot water treatment was slightly beneficial up to a temperature of 120°. All the hot water treatments above 130°–135° fifteen minutes were injurious, 140°–145° injuring the corn very seriously.

3. With the 8-rowed corn the hot water had less marked effects either beneficially or injuriously; with a few slight exceptions there was no evidence of injury from even the most extreme treatments.

*Copper sulphate 6 lbs., lime 4 lbs., water 22 gals.

4. Soaking in the Bordeaux mixture for one hour and less had no perceptible effect, and soaking six hours was slightly beneficial.

5. Soaking in copper sulphate solutions of either strength for lengths of time up to 15 minutes had no apparent injurious effect. Soaking one hour was slightly injurious.

X. LETTUCE MILDEW AND LETTUCE ROT.

Lettuce Mildew.—Upon starting the new green house in December, seedling lettuce plants were gotten from Boston. Soon afterward the *lettuce mildew* (*Peronospora gangliformis*, (B.) DBy.) appeared upon them and threatened to do very disastrous work. The house was thoroughly disinfected with sulphur fumes. This entirely destroyed the fungus, not a sign of this disease having been seen since.

Lettuce Rot.—Much trouble and serious loss was experienced however, during the entire winter with the *lettuce rot* both in our own house and that of others in the city. This trouble appeared only in the *head* lettuce varieties, the Grand Rapids and other crinkly leaved varieties not being attacked. There was rarely any sign of disease, until, just as the plants began to head out, the tips of the larger, outer-most, leaves would curl and turn brown at the tips; later the young forming head would die and often rot away. Prof. J. E. Humphrey of the Massachusetts Experiment Station attributes this trouble to the attack of the fungus *Botrytis vulgaris*, Tr. The fruiting fungus was found abundantly upon the decaying leaves, in the more advanced stages of the disease appearing as a dusty grayish mould. This is an extremely hard fungus to destroy from the green-house since it is saprophytic in its habits growing very generally upon decaying leaves or other vegetable matter. Its attack upon the lettuce at the time of heading and not before may be due to the weakened condition of the young plant resulting from the rapid growth at this stage.

XI. VERMONT WEEDS.

There are but few weeds that are hard to keep in subjection where the land is ploughed and used for a rotation of crops. The trouble is much more serious however on the stony hillsides that are used as pastures and which cannot be ploughed. Here the brake, sorrel, hardhack, golden rod, moss, white-top, live-for-ever and raspberry are hard to keep out.

Believing that it would prove of practical value as well as of interest to learn what weeds are most troublesome in different portions of the State, copies of a list of the more common weeds were sent or handed to a

number of farmers, chiefly through the aid of the State Board of Agriculture, with the request that each farmer check upon this list the names of the ten weeds he found most troublesome, placing a 1 before the one he considered worst, 2 before the next worst, etc. Forty marked lists have been returned up to date. While the entire State is not fairly represented in these replies, it is hoped to get further information, and it will be of interest to publish these results as preliminary to further inquiry.

In order to make the matter as easily comprehensible as possible these results are placed in tabulated form. A little explanation will make the table more clear. Since various names are given to the same plant in different neighborhoods a list of these various names is given in each case. The last ten names were not on the original list; if they had been they would probably have received more votes.

Following each name is a statement of the ranks given it in the various reports, thus for the Daisy: in three reports it was given 1st place (as worst) in five it was placed 2d, in four it was 3d, etc. The total number who checked the Daisy in their lists is given in the last column as 24. Considering both the number of the votes and the rank given, the worst ten according to these reports, would be 1 quack grass, 2 white daisy, 3 kale, 4 live-for-ever, 5 hawkweed, 6 lance-leaved plantain, 7 wild carrot, 8 brake, 9 yellow dock, 10 Canada thistle.

COMMON NAME.	BOTANICAL NAME.	Relative Obnoxiousness. 1 st.	2 d.	3 d.	4 th.	5 th.	6 th.	7 th.	8 th.	9 th.	10 th.	above 10th.	Total No. Votes.
Oxe-eye Daisy, White Daisy	Chrysanthemum Leucanthe-	3	5	4	1	3	2	1	0	3	2	0	24
	mum, L	2	4	1	2	2	0	1	0	1	2	0	15
Wild Carrot	Daucus carota, L	2	2	3	3	2	2	2	3	2	2	1	24
Kale, Charlock, Wild Mustard	*Brassica Sin'trum, Boiss												
Ragweed, Roman Worm-wo'd	Ambrosia artemisiaefolia, L	0	1	3	1	1	3	1	2	0	2	1	15
Hawk-weed, Ladies' Paint Brush	Hieracium aurentiacum, L.	4	0	0	0	1	1	0	2	6	0	1	10
Quack, *Knot-grass, Witch-Grass	Agropyrum repens, Beauv	7	0	2	3	2	2	0	1	2	0	0	19
Pigweed, Hog-beet, Green Amaranth	Amarantus retroflexus, L	1	1	1	2	0	2	2	1	1	1	1	13
Lance-leaved Plantain, Rib-grass, English Plantain	Plantago lanceolata, L	2	4	2	2	1	0	2	1	1	2	1	18
Pigweed, Lamb's quarters, Goose-foot	*Chenopodium album. L	0	1	0	0	2	1	0	2	0	2	0	8
Purslane, Pusley	Portulaca oleracea, L	0	2	1	2	4	1	1	0	2	2	2	18
Sheep Sorrel, Red Sorrel	Rumex acetosella, L	1	1	4	1	0	1	1	1	3	2	2	17
Chicory	Chicorium Intybus, L	3	1	1	2	0	0	1	0	0	1	1	9
Shepherd's Purse	Capsella Bursa-pastoris, Moench	0	0	0	0	0	0	1	1	0	0	1	3
Canada Thistle	Cnicus arvensis, Hoff	0	3	2	2	3	0	2	4	2	3	0	21
Yellow Dock, Curled Dock	*Rumex crispus, L	1	1	1	1	3	2	1	2	5	2	1	20
Pigeon Grass, Fox Tail	*Setaria glauca, Beauv	0	1	0	0	0	3	0	1	1	1	0	7
Barn-yard Grass	Panicum Crus-galli, L	0	1	4	1	0	0	0	0	2	0	2	10
Crab Grass, Finger grass	Panicum sanguinale, L	0	0	0	1	0	0	0	0	1	0	0	2
Burdock	Arctium Lappa, L	0	1	1	0	1	3	0	2	6	1	2	17
Chickweed	*Stellaria media, Sm	0	0	0	0	1	1	1	0	2	1	1	7
Mallow, Cheeses	Malva rotundifolia, L	0	0	0	1	1	0	0	1	0	1	1	5
Brake (in dry pastures)	*Osmunda cinnamonea, L	2	1	4	1	3	1	2	1	3	0	0	18
Fern (in wet meadows)	*Onoclea sensibilis, L	0	0	1	0	1	1	1	1	0	0	1	6
Wild Sun-flower, Yellow Daisy	Rudbeckia hirta, L	1	1	0	0	1	0	1	0	2	3	0	9
Pitchforks, Sticktights	*Bidens frondosa, L	0	0	0	0	0	0	0	1	1	0	1	3
May-weed	Anthemis cotula, Dc	0	0	0	0	0	0	0	0	0	0	0	0
Hardhack	*Spiraea tomentosa, L	0	2	1	3	2	1	1	0	1	0	0	11
Golden Rod	Solidago spp	0	1	3	1	0	0	0	4	2	2	2	15
Moss, Hair-cap	*Polytrichum commune	0	1	0	1	0	2	1	1	0	3	0	9
Wild Parsnip	*Pastinacea sativa, L	0	1	0	2	1	1	1	1	1	2	1	11
Toad-flax, Butter and Eggs	Linaria vulgaris, Moen	0	0	0	0	0	0	0	0	0	0	0	0
Sow Thistle	*Sonchus oleraceus, L	0	1	0	0	0	0	1	1	0	1	0	4
Wild Morning Glory, Bindweed	*Convolvulus sepium, L	1	1	0	0	0	0	0	1	1	0	0	4
Wild Buckwheat, Black Bindweed	*Polygonum convolvulus, L	0	0	0	0	1	1	2	1	1	0	0	6
Live-for-ever	*Antennaria pl'folia, Hook.	4	1	0	0	2	4	1	0	0	3	2	17
White Top, Wild Oat Grass	Danthonia spicata, Beauv	1											1
Wild Bergamot	Monarda fistulosa, L											1	1
Milkweed	*Asclepias Cornuti, Dec											1	1
Smartweed	*Polygonum Hydropiper, L											2	2
Buttercup	Ranunculus acris, L							1					1
Blue Thistle	Echium vulgare, L											1	1
Raspberry	*Rubus strigosus, Mx						1						1

*This is the most common species, but other closely related plants are known by the same common name,

REPORT OF THE ENTOMOLOGIST.

G. H. PERKINS.

THE WHITE GRUB.

A study of the life history of Lachnosterna and of remedies against its attacks.—Few of our common injurious insects have been so long known, so often more or less fully described and so imperfectly understood, as has the May Beetle and its larva, the White Grub. This insect is often mentioned in the writings of the earlier entomologists of this country and has been time and again described, figured and discussed in later reports and all of these have contained erroneous statements and have never presented anything like a complete life history of the insect. Even now an absolutely complete life history can not be given of most, if of any, of the numerous species which are included in the genus *Lachnosterna.* Recent observations have added much to our knowledge of the genus and removed much error, and the study of remedies by which the larvæ may be destroyed, or at least held in check, has not been without substantial results. It is well to state that there are good reasons why our knowledge of the beetle and grub has hitherto been so imperfect and that it is not wholly due to carelessness or inefficiency on the part of observers. The names of some of those who have given accounts of it are evidence that this is not true, but, rather, it is because the habits of the beetle in its larval and adult states are such that they have not readily been discovered in all their details. Only continuous, patient, careful and prolonged observation could decide many questions that the history of this insect called up and many persons otherwise well equipped to answer them were obliged from lack of time to leave them unanswered.

The time and labor involved in working out the life history of any single insect may be very considerable and the insects are many while the laborers are few. Yet it is obvious that the first condition of success in fighting any injurious insect must be a knowledge of its habits, transformations, and all that makes up its biography from the beginning to the end of its life. Without this knowledge all efforts at extermination are of little avail, for we are working in the dark and at random; we may hit and we may as easily miss the foe at which we strike, but with this knowledge our efforts must be far more successful, if not completely so.

The writer must in all honesty confess his own faults respecting the *White Grub.* In the Second and Fourth Reports of this Station and in

247 pounds. During our tests in 1889, the pigs required 2.79, and in 1891, 2.82 pounds of dry matter in the food for a pound of growth, but in both these cases the pigs were grown to but a live weight of 200 pounds, and further growth would have required a much larger amount of food.

FINANCIAL SUMMARY.

The pigs gave a gain over the cost of their feed. They increased in live weight 1918 pounds, which sold for $112.91, while the food they ate cost $73.68, a profit of **$39.23** using the same figures as above, of $22 per ton for corn meal, $17 per ton for wheat bran, and 15 cents per hundred pounds for skimmilk.

VALUE OF SKIMMILK.

In the above figures the skimmilk has been given an assumed value of 15 cents per hundred pounds. The only reason for keeping and feeding the pigs is to serve as a method of utilizing the skimmilk. It would be a proper method of accounting, to take out from the amount received for the pork, the cost of the grain fed, and consider the balance as what was received for the skimmilk. The pigs were sold for $112.91, and they ate $44.11 worth of grain, which leaves $68.70 as the amount realized for the 19,712 pounds of skimmilk they ate. This would be equivalent to **35** cents per hundred pounds.

FERTILIZING VALUE OF FEED.

This has been alluded to many times, but will bear repeating. Skimmilk especially is very rich in plant food. It is worth about **11** cents per hundred pounds to pour out on the ground as a fertilizer in addition to its feeding value, which has been shown above to have been in this experiment 35 cents per hundred pound, making a total value of **46** cents. And yet at most creameries farmers are willing to sell it for less, even, than its fertilizing value.

COMPOSITION OF FEED IN POUNDS PER TON.

	Nitrogen.	Phosphoric Acid.	Potash.	Valuation.
Skimmilk	11.0	4.1	4.2	2.29
Corn Meal	29.0	12.8	8.0	6.04
Wheat Bran	49.7	60.7	31.3	13.42

The total fertilizing value of the food eaten by these eight pigs is $38.09, from food costing $73.68, the fertilizing value thus representing **51** per cent of the market value of the food.

REPORT OF THE BOTANIST.

L. R. JONES.

As in previous years, most of the investigations of this department have been on plant-diseases and their remedies. The most interesting and important results will be found in the report of the work upon Potato Blights and Oat Smut.

More time and attention than in former years has been given to the placing of the most important results of the work on plant diseases before the farmers. One Bulletin* and a Circular Letter** have been published, in addition to newspaper and personal correspondence and lectures before farmers' meetings.

Considerable time has been given to the collecting and preparing of specimens illustrating the diseases of certain garden vegetables. This collection now forms a part of the united exhibit of Experiment Stations at Chicago, and will be returned at the close of the World's Fair, to form part of our museum.

The following is a list of the subjects of this report in their order :

I. Potato Diseases :

(a) A comparative test of fungicides for the Late Blight. (*Phytophthora infestans, D. By.*)

(b) The new disease, or Early Blight, (*Macrosporium Solani, E.& M.?*)

(c) The Scab.

II. Oat Smut :

(a) Experiments with remedies for Oat Smut.

(b) Investigations as to the losses from Oat Smut in Vermont.

III. Orchard Diseases :

(a) Experimental work in Spraying for Apple Scab.

(b) A Leaf-Spot Disease of Apples. (*Phyllosticta pirina, Sacc.*)

(c) Apple-Rust and Cedar-Apples. (*Roestelia pirata, Thaxter.*)

IV. A Cucumber Spot Disease. (*Cladosporium cucumerinum, E. & A.*)

V. Green-house Diseases.

(a) Lettuce Rots.

(b) Oedema of the Tomato.

*No. 28. See abstract on p. 24.

**On Potato Blights.

I. POTATO DISEASES.

(a) A COMPARATIVE TEST OF FUNGICIDES FOR THE LATE BLIGHT AND ROT.
(*Phytophthora infestans, D. By.*)

Experiments in previous years have shown beyond question the value of the Bordeaux mixture as a remedy for this potato disease. This fungicide being, however, one of the most inconvenient of the copper mixtures, we were led in 1891 to test some of the other copper salts in the hope of finding a substitute for it. The results of that work,* though not conclusive, were all in favor of the Bordeaux mixture. We felt that the importance of this work was such that we made it the chief problem in our experiments this last summer, (1892).

For the test we selected twelve of the most promising fungicides, including three strengths of Bordeaux mixture.

The tests were made in three fields. Field A, was planted May 20, to "White Star" potatoes; Field C was planted at about the same date with mixed seed, mostly "Early Rose;" Field B was planted to four varieties of potatoes, "Garfield," "Polaris," "Mrs. Foraker," and "Early Rose," very late, June 12, in order to be sure to escape the complication of the "new" disease with the *Phytopthora*, which interfered with experiments the year before.† The *Phytopthora* came early enough this time, however, to avoid this trouble.

Since the results in Field B were in all respects in accord with those in Field A, we will, for the sake of simplicity, base most of our statements upon the results from Field A, citing the results from Field B only as may be desirable for confirmatory evidence. In Field C only one application was made, the result of which is considered by itself on page 64.

FIELD A.

During June and July, dressings of Paris green for the beetles were applied as necessary. July 30th, all parts of the field were alike in healthy condition. Sixteen plots were then staked out, two rows in each plot, thirty-three hills in each row. The rows ran north and south. Twelve of these plots were then sprayed as follows, five plots being left untreated as checks :

1. Untreated.
2. Copper Soda Solution—8 lbs. copper sulphate, 12½ lbs. sal soda, 50 gals. water.
3. Verdigris Solution—5 lbs. verdigris, 50 gals. water (reduced one-half after first application).
4. Bordeaux Mixture and Molasses—8 lbs. copper sulphate, 8 lbs. lime, 8 lbs. molasses, 50 gals. water.

*See Rep. Vt. Exp. Sta. 1891, p. 130.
†Rep. Vt. Exp. Sta. 1891. p. 131.

5. Ammonical Copper Carbonate—5 oz. copper carbonate, 3 pints strong ammonia, 45 gals. water.
6. Untreated.
7. Strong Bordeaux Mixture—6 lbs. copper sulphate, 4 lbs. lime, 22 gals. water.
8. Weak Bordeaux Mixture—5 lbs. copper sulphate, 5 lbs. lime, 50 gals. water.
9. Very Weak Bordeaux Mixture—1 lb. copper sulphate, 1 lb. lime, 30 gals. water.
10. Copper and Ammonium Carbonates—1 lb. copper carbonate, 2 lbs. ammonium carbonate, 50 gals. water.

11a. Untreated.

Several rows here omitted on account of low ground.

11b. Untreated.

12. Glue Mixture—10 oz. copper sulphate, 12 oz. sal soda, 8 oz. liquid glue, 25 gals water.
13. Modified Eau Celeste—4 lbs. copper sulphate, 5 lbs. sal soda, 3 pints ammonia, 45 gals. water.
14. Copper Carbonate in Suspension—1 lb. copper carbonate (precipitated), 25 gals. water.
15. Copper Chloride Solution—3 oz. copper chloride, 22 gals. water.
16. Untreated.

The weather for the next three weeks was quite rainy. August 10th the first of the *Phytophthora* was found, only a few leaves on Plot 1. It continued warm and rainy during this night, and the next day. August 12th, the disease was found on every untreated plot (Plot 1, 6, 11a, 11b, 16), but not a single blighting leaf could be found on any one of the sprayed plots, excepting the plot sprayed with Ammoniacal Copper Carbonate (Plot 5), where several hills showed the disease badly. August 13th, a second application of all the mixtures was made of the same strengths as the first, except on Plot 3, where the Verdigris solution was reduced to half its former strength, owing to the evident injury to the foliage from the first application. August 25th a third application of all the fungicides was made similar to the second, except that ten hills in the middle of each row were left unsprayed.

Thus the middle third of each plot was left with only two applications, while the two outer thirds had three applications. This was done in order to test the relative gains from two and from three applications. At this time, practically all of the leaves on the untreated plots were dead, and the plots to which the weaker fungicides had been applied, were so badly diseased that this comparative test of the two and the three applications was of value only in the cases of the stronger fungicides, as shown in the table on page 63.

September 8th the following conditions were noted:

Plot 1. Every leaf dead and dry.

Plot 2. All dead except a few plants at one end.

Plot 3. Apparently this mixture equals the last as a fungicide, but the leaves not attacked by the blight are badly burned by the mixture.

Plot 4. In fine condition, scarcely a diseased leaf on entire plot.

Plot 5. Every leaf dead and dry.

Plot 6. Every leaf dead and dry.

Plot 7. Entirely free from disease, though owing to soil, not quite so thrifty as Plot 4.

Plot 8. Nearly equal to Plot 7, though not quite.

Plot 9. About half the foliage dead.

Plot 10. Most of leaves dead. Not equal to 9.

Plot 11a. Every leaf dead and dry.

Plot 11b. Every leaf dead and dry.

Plot 12. Nearly every leaf dead and dry.

Plot 13. Considerable blight, especially at one end.

Plot 14. Only a few green leaves left.

Plot 15. Every leaf dead except a few on two hills.

Plot 16. Every leaf dead and dry.

In order to show more clearly the conditions at this time, a number of photographs were made. Some of these are reproduced in Plates I, II and III. Plate I shows a single hill from each plot, selected as a sample of that plot. Plates II and III show Plots 4, 5, 6 and 7, entire, with their respective yields, as photographed later, shown above them. A study of these plates will give some idea of the striking constrasts between some of the plots at this time, especially Plots 4, 5, 6 and 7.

When dug, the difference in yields was no less striking than this difference in appearance of the tops. Owing to the rainy weather of July and August, the varying conditions of the plots, as to surface drainage, make comparisons of yields of rows much separated, misleading. These differences would not have amounted to so much in a dry season, but during the very rainy weather of August, water stood much of the time between the rows in some portions of the field. This, of course, prevented the normal growth of tubers in these lower places, and also led to more loss from rot.

Plots 8 and 9 were in the lowest portion of the field, and suffered most from this standing water, their yields as shown in the accompanying table being less than that of Plot 10, although as shown by the condition of the foliage and also by the weight of rotten tubers the fungicides on both 8 and 9 were superior to that on 10. Plots 1 to 4 may be fairly compared with each other, as may Plots 5 to 7, Plots 10 and 11a, and Plots 11b to 16. The larger yield of Plot 4, as compared with Plot 7, was not due to the superior fungicidal value of the molasses mixture used on Plot 4, as was

clearly shown by the condition of the foliage and the amount of rot, but was entirely due to soil conditions. The duplicate work in Field B. helped much in deciding such questions, as may be seen by the following table :

YIELDS FROM FIELD A.						YIELDS FROM FIELD B.
No. of Plot.	Fungicide Used.	Large Sound Tubers. Bu. per Acre.	Large Rotting Tubers. Bu. per Acre.	Small Sound Tubers. Bu. per Acre.	Small Rotting Tubers. Bu. per Acre.	Large Sound Tubers. Bu. per A.
1	None	184¾	32	54¾	5	44
2	Copper-Soda	299	34	42	8¼	76
3	Verdigris	258¼	5	63¼	1⅝	98
4	Bord. M. & Molasses	354½	2⅕	46	½	161⅔
5	Am. Copper Carb.	105½	21¼	38	8¼	116
6	None	99½	24¾	50½	6	85⅛
7	Strong Bord. Mix.	291¼	2	58	0	186⅛
8	Weak Bord. Mix.	164	4½	66½	¼	180⅓
9	Very Weak Bord. M.	139½	16	60	4¾	119⅛
10	Cop. & Am. Carb.	171½	23½	41¼	5⅕	116⅔
11a	None	114¾	38	50	17½	123⅛
11b	None	232	7⅛	47¾	1⅝	
12	Glue Mixture	258½	3¾	40	⅞	172⅔
13	Mod. Eau Celeste	291	1¾	34¼	⅛	242
14	Copper Carbonate	256	⅛	27½	⅛	230
15	Copper Chloride	186	5½	32¾	¾	170
16	None	207	19	42½	4	124

The yields in Field B, given in the last column above, may also prove misleading if the attempt be made to compare widely different plots, as for example, 7 and 13. If, however, the yields of adjacent check plots be taken into consideration, this matter is easily corrected. For example, Plot 13, when compared with checks 11 and 16, shows a gain of 95 per cent, while Plot 7, as compared with check 6, shows a gain of 119 per cent, indicating clearly the superiority of the fungicide used on Plot 7 to that used on Plot 13. The yields from Plot 1, and in less degree, Plot 2, were abnormally low from lying alongside a roadway at the margin of the field.

CONCLUSIONS AS TO THE RELATIVE VALUES OF THE TWELVE FUNGICIDES TESTED.

Judging from appearance of the plants in the two fields, and from the yields as given above, we would rank the various fungicides tested in the following order of merit :

Rank.	Treatment.	Plot No.	Remarks.
1	Strong Bordeaux Mixture	7	These four are the only ones of sufficient merit to recommend them for practical use.
2	Bordeaux Mixture and Molasses	4	
3	Weak Bordeaux Mixture	8	
4	Modified Eau Celeste	13	
5	Copper-Soda Solution	2	These were all beneficial, most of them to a profitable degree, but not to be ranked with the other four.
6	Verdigris	3	
7	Very weakBordeaux Mixture	9	
8	Precipitated Copper Carbonate	14	
9	Copper and Ammonium Carb.	10	
10	Glue Mixture	12	
11	Copper Chloride	15	
12	Ammoniacal Copper Carbonate	5	

The above conclusions answer, so far as the work of a single season can do it, the main question raised in this experiment. The Bordeaux mixtures have stood in all our tests without a rival in checking *Phytophthora.* The addition of molasses increased the value of the mixture little, if any, and we do not recommend it.* The most surprising outcome of our experiments has been the utter failure of the Ammoniacal Copper Carbonate. We believe, however, that our conclusion as to this solution will stand the test of further experiment as we had the same experience with it in 1891. In a dry season it would doubtless prove much better comparatively, but during dry weather there is nothing to fear from this disease—it is wet weather, protracted rains, that bring on the blight, and at such times the weaker fungicides are either washed away or so much diluted as to be of little protection. It is still an open question, in our mind, whether we can afford to use the weak Bordeaux mixture in preference to the strong. We think that the observing man will soon learn to suit the strength of mixture to his particular need. When the disease is especially threatening a stronger mixture is called for, but when the season is dryer and the application is merely a precautionary one, the weaker mixture can safely be used. Again the strength of the solution should bear some relation to the apparatus for applying. If that apparatus be supplied with good Vermorrel nozzles and well-managed, then we can afford to use the strong mixture; if, however, it is applied with some coarser nozzle, or (as is done, and successfully too, in many potato fields in this State) with a watering pot, or with pail and brush-broom, then a weaker solution should be used in proportion as more liquid is thrown upon each leaf.

*The danger to bees from the addition of molasses or any sugar solution to a mixture containing Paris green, is worthy of consideration. The question was laid before the Vermont Bee Keeper's Association at their annual convention, Dec. 28, 1892. This Association, after discussing the question, passed the following resolution:

Resolved; "That we, as bee keepers, apprehend danger from the addition of sugar to poisonous solutions used in spraying potatoes."

WHAT WAS THE ACTUAL GAIN FROM SPRAYING.

This is the important practical question constantly asked. The table on the preceding page (page 60) shows conclusively that from the use of the better fungicides we realized gains of from 60 to 200 bushels and more per acre, amounting to from 25 per cent to nearly 200 per cent. As the possible gains are determined by the actual losses from the disease, and these losses varied in different parts of the same field, the average gain may be better gotten at from the following summary of the yields of the four plots in fields A and B, sprayed with the better fungicides as contrasted with those check plots which may fairly be compared with them. It will be seen that where there was doubt as to which check plot should be taken, we have always taken the one giving the larger yield, hence the average gain is underestimated rather than overestimated.

FIELD A.

Sprayed Plots.			Check Plots.	
No. 4.	Bord. Mix. and Mol. ..	354½ bu. per acre.	No. 1.	184¾ bu. per acre.
No. 7.	Strong Bord Mix.......	291¼ "	No. 6.	99½ "
No. 8.	Weak Bord. Mix.......	164 "	No. 6.	99½ "
No.13.	Mod. Eau Celeste......	291 "	No.11b.	232 "
	Average yields.....	**275** bu. per acre.		**155** bu. per acre.

Average gain: **120** bu. per acre = **78** per cent.

FIELD B.

Sprayed Plots.			Check Plots.	
No. 4.	Bord. Mix. and Mol. ..	161⅜ bu. per acre.	No. 6.	85⅛ bu. per acre.
No. 7.	Strong Bord. Mix.	186⅛ "	No. 6.	85⅛ "
No. 8.	Weak Bord. Mix.......	180⅛ "	No. 6-11.	104⅛ "
No.13.	Mod. Eau Celeste......	242 "	No.11-16	124 "
	Average yields.....	**193** bu. per acre.		**100** bu. per acre.

Average gain: **93** bu. per acre = **93** per cent.

AVERAGES OF FIELDS A. AND B.

Sprayed, 239 bu. per acre; Checks, 127 bu. per acre; Gain **112** bu. per acre = **88** per cent.

Taking the averages for the three Bordeaux Mixtures in the two fields, we have:

FIELD A.		FIELD B.	
Sprayed.	Check.	Sprayed.	Check.
270 bu. per acre.	128 bu. per acre.	176 bu. per acre.	92 bu. per acre.
Gain: 142 bu. per acre=111 per cent.		Gain. 84 bu. per acre=91 per cent.	

Average of A and B: sprayed, **223** bu.; checks, **110**; gain, **113** bu.=**103** per cent.

RELATIVE GAINS FROM TWO AND FROM THREE APPLICATIONS.

As stated on page 58, the middle third of each plot in Field A, was left with only the two applications made July 30th and August 13th, while the two outer thirds were given a third application August 25th. The value of this third application is evident from the following tabulated statement of the results:

Plot.	Fungicide.	I. Sprayed 3 Times.	II. Sprayed Twice.	III. Sprayed 3 Times.	Average I. & III.
4	Bord. Mixt. & Mol..	428½	265¾	280	354¼
5	Am. Cop. Carb......	128	86	82	105½
6	None...............	123	86¾	75½	99¼
7	Strong Bord. Mixt...	369¼	157	213½	291¼

Comparing these figures we find:

Averages of 4 and 7, where sprayed three times: 323¼ bushels per acre.

Averages of 6 I and 6 III, checks on this last: 99¼ bushels per acre.

Gain from three applications **224** bu. = **222** per cent.

Average of 4 and 7, where sprayed twice: 211 bushels per acre.

Yield of 6 II, check on this last: 86¾ bushels per acre.

Gain from two applications: **124** bu. = **143** per cent.

The gain from the third application, therefore, was **79** per cent or a little over one-third of the total gain. The plants that received the third spraying lived considerably longer than those receiving only two applications.

These results should not be interpreted, however, as indicating that similar gain would result from a third application every year; that will depend, of course, upon the conditions of weather.

THE RESULTS IN FIELD C.

This was a piece of rather early potatoes, which was left with no treatment until August 15th, nearly a week after the first of the blight was seen. At this time the disease had gotten a pretty strong start. Fourteen plots were staked off, three were left as checks and to the other eleven fungicides were applied, the same as in the Fields A and B, except that Verdigris was dropped from the list. August 25th, when these plots were next examined, they were all badly diseased, and it was evident that even the strongest mixture had done but little good. In a few days more all were dead; when dug no appreciable gain was found from any of the treatments.

This experiment is especially significant when compared with results of a similar experiment in 1891. Then the blight came later and spread much more slowly, so that one field left until August 22d before spraying was preserved in good condition. (See Report 1892, p. 129.)

EXPENSE OF SPRAYING.

We are often asked how much does it cost per acre, chemicals and labor, to spray potatoes. We attempted an answer to this question last year in Bulletin 28. After another year's experience, we again give our opinion. It is impossible to give a general estimate that will suit all cases, as there are so many varying conditions. The amount of the mixture necessary to cover an acre will vary all the way from 50 to 300 gallons, according to the amount of foliage and the method of application. Where we have covered an acre with 50 gallons in the middle of July, we have used 100 and 150 gallons per acre on the same piece in August. Again, in the latter part of August, we have sprayed a poor piece of half-blighted plants with 100 gallons per acre, and on the same day, on another piece where the ground was covered with the mass of luxuriant leaves, we have found it necessary to use fully 250 gallons per acre. Again, as shown above, the number of applications varies with seasons. In 1891 a single application made August 20th, was sufficient on a piece of late potatoes, while in 1892 three applications were necessary. In general, we should plan for making three applications on all except very early or very late potatoes. These three applications will require from 200 to 500 gallons of the mixture, on the average 400 gallons used as follows:

100 gallons per acre the last of July.
150 " " " " middle of August.
150 " " " " last " "

This estimate is for a field planted about May 15 to May 20, and which will yield 200 bushels per acre. In our work, it has taken (for three applications) about 2 gallons of mixture per bushel of yield. On early potatoes a fourth application may sometimes be necessary to keep off the Early Blight,* the first application being made the first week of July; in this case

*For discussion of this disease see page 66.

it will take about 2½ gallons per bushel of yield. The mixture costs us about three-fourths of a cent per gallon as follows :

5 pounds blue vitriol at 7 cents	.35	cents.
5 " lime " ½ cent	2½	"
Total cost of 50 gallons weak mixture	37½	cents.

As most potato growers have to pay a little more than this for blue vitriol, one cent per gallon is about the average cost. The cost of applying also varies much, depending upon luxuriance of growth of plants, and upon apparatus used. In our work, with a barrel-pump, three men and one horse have sprayed an acre well in two hours, when water was convenient, or at the rate of five acres a day, making the expense for labor about $1.00 per acre. Others with similar apparatus, have said they could cover ten acres per day. We trust that some form of pump especially adapted for spraying potatoes will soon be placed on the market that will lessen this part of the expense.

SUMMARY OF COST OF SPRAYING ONE ACRE OF POTATOES.

Mixture for three applications—	Minimum.	Maximum.	Average.
200 to 500 gallons at one cent per gallon	$2 00	$5 00	$4 00
Labor	1 50	3 75	3 00
	$3 50	$8 75	$7 00

When we consider our gain of an average of 113 bushels per acre, worth last fall 80 cents per bushel, or $90.40, the profit is great, even at the maximum expense. In our work during the past three years, in every case where we have used the mixture, the gain has been great enough, even when potatoes were at their lowest price, to much more than cover this maximum expense.

WHY IS THE YIELD INCREASED BY SPRAYING?

No potato-grower who visited our potato-field last September doubted the advantages of spraying, yet when we present the figures which show how much our yield was increased by spraying we presume few farmers will be ready to believe that this doubling of their crop is a possible thing for them; or, to put it in another way, that they lost half of their possible potato crop last summer where they did not spray. Many potato-growers think that their chief loss from this disease is from the rotting of the tubers. As indicated in Bul. 28 (p. 22), the great loss from our potato blights is not from the rotting of the tubers, but from the premature death of the vines. This is clearly shown by the figures in the table of yields of Field A, on page 60. Take plots 6 and 7 for example :

Plot 6: Large sound 99½ bu. per A.; large rotten 24¾ bu. per A.

Plot 7: Large sound 291¼ bu. per A.; large rotten 2 bu. per A.

By checking the rot then in Plot 7, we gained only 23 bushels. The total gain from the spraying was, however, 192 bushels per acre. Subtracting 23 bushels from 192 bushels leaves 169 bushels gained from checking the blight on the leaves, and thus prolonging the life of the vines from the middle of August, when the unsprayed plants died, to the latter part of September, when the sprayed vines ripened. The fact cannot be emphasized too strongly that even on the wettest portion of this field, where one-quarter of the tubers were rotten, this loss from rot was *only one-seventh* as much as was the loss from early death of the vines. *If every Potato-grower in Vermont could realize that his loss from rot last year, severe as it was, represented only one-eighth of his actual loss, it would arouse an interest in the value of fungicides as nothing yet has done.*

Each year we have studied this question we have become more convinced that few even of our observing potato-growers realize their loss from the premature death of the vines. We believe that could the facts be known, from experiments made in all the potato fields of the State similar to that in our own fields, it would be found that the potato crop of Vermont was reduced last summer fully one-third, from the premature death of the vines.

(b) THE NEW POTATO DISEASE OR EARLY BLIGHT.

In our last report (Rep. 1891, p. 131) a "new" * potato disease was mentioned. This trouble was still worse in 1892. Large numbers of specimens

*It is not at all certain that this disease is a new one. It is more probably a general recognition of an old trouble which has been confused with the *Phytophthora* blight. What appears to be the same trouble is common in many parts of the country and apparently has been for years, as may be seen from the following notes:

In Vermont, there has been a similar trouble since 1889, at least.

In Iowa, Prof. Pammel says it "has been common for several years."—Ia. Bul. 20, p. 719.

In Wisconsin, Prof. Goff describes a similar trouble and says, "How long it has prevailed in Wisconsin is not known, but it probably is not of recent introduction."—Wis. Bul. 34, p. 8.

In Canada, Prof. Fletcher reports this trouble common and destructive in Ottawa.—Rep. Exp. Farms 1892, p. 164.

In Delaware, Prof. Chester found this trouble serious in 1891 [Del. Bul. 15 p. 14], and writes of its presence in 1892.

In Massachusetts, Prof. Humphreys found it injurious in 1891, and also 1890 [Mass. Rep. 1891, p. 226], and wrote of its presence in 1892.

In Connecticut, Prof. Sturgis noted serious blighting of potatoes from some unknown cause, not *Phytophthora*.—Conn. Rep. 1892, p. 41.

"Prof. Galloway writes that he finds *Macrosporium Solani* constantly associated with certain diseases of the potato."—Ia. Bul. 20. p. 719.

In this connection the following letter, just received from Dr. J. B. Ellis, of Newfield, N. J., will prove of interest:

"*Macrosporium Solani*, E. and M., was published in Am. Nat. Dec., 1882, p. 1003. In Grevillia, Sept., 1883, p. 32, Cooke published the same thing under the same name, i. e., *Macrosporium Solani, Cke.*, having probably overlooked our publication. Cooke found it on *Datura Stramonium*. It seems to me, as you say, that this thing may have been growing on potato leaves for a long while, but it has not been specially injurious until lately, when peculiar atmospheric conditions, or some other cause unknown, have caused it to grow more luxuriantly."

were sent to us for examination from various parts of the State. We are still in some doubt as to the cause of part of this trouble, and do not think that any one thing is wholly responsible. Leaves that had been attacked by insects seemed to suffer worst, many of the dead spots having at their center one or more of the holes eaten by the flea-beetles. Large numbers of leaves were sent to us that had evidently been killed by too much Paris green, some of them being literally coated with this poison. It may not be out of place to suggest that danger of killing the foliage from Paris green is lessened if a little fresh lime is added to the Paris green water.*

But neither Paris green nor insect injuries can account for all of the serious blighting of early potatoes throughout the State last summer. The trouble began to show about the middle of July, and by the first of August was general and serious. The leaves blackened and curled at the tips and edges first; or often spots appeared scattered over the leaf, which gradually enlarged and merged together. Owing to this slow progress the dead parts generally became dry and crisp, and often broke away leaving the leaf ragged.

In many leaves examined we were unable to find any trace of fungous attack. In the large majority, however, we found a *Macrosporium* apparently *Macrosporium Solani, E. & M.* Specimens were sent to Prof. B. T. Galloway, who pronounced it this species.

As no cultural experiments or inoculations were made, we cannot say with certainty that this *Macrosporium* is the cause of this disease,† yet the general association of this fungus with the disease leaves little doubt in our minds that it was the cause of a large part of the trouble last summer. Apparently insect punctures or other injuries to the leaf, offer a favorable starting point for this fungus.‡ The further fact should be noted that this

*"By the addition of a little lime to the mixture, London purple and Paris green may safely be applied at the rate of 1 pound to 125 to 150 gallons of water to the tenderest foliage, or in much greater strength to strong foliage, such as that of the apple" [or potato].—C. V. Riley, Farmer's Bul. No. 7, U. S. Dept. Agric.

"One of the best ways of doing this is to add three-fourths of a pound of lime to a pound of the London purple [or Paris green] and thoroughly mix them in a gallon of hot water, allowing the mixture to stand two hours and keeping it hot during this time if it can conveniently be done."—C. M. Weed, "Spraying Crops," p. 20.

†Prof. Chester of the Delaware Station, writing concerning a similar blight in that State, says, "from artificial infection with the spores of *Macrosporium Solani* there is little doubt that this is the true cause of the trouble. Del. Exp. Sta. Bul. IV.

‡See also circular letter issued from this Station Aug. 12, 1892.

Similar association of this disease with insect injuries is mentioned by Prof. Chester, Del. Bul. XV. p. 13; Prof. Fletcher of Canada, Rep. 1892, pp. 163-3; Prof. Goff, Wis. Bul. 34, p. 8.

disease does little damage until after the plants blossom and pass their stage of greatest vigor. Many potato growers were misled by this fact into believing that their potatoes merely "ripened off" unusually early last summer. The lightness of the yield and the appearance of the tubers show, however, that the vines died prematurely. Where we examined the tubers of these early potatoes, their appearance indicated immaturity, and in this opinion we have been confirmed by some of our best practical potato growers. We believe that few, if any, early potatoes in the State matured fully last summer, and, as explained on page 66, such premature death of the vines always means a serious shortening of the crop, aside from injury to its quality. Many potato-growers who realized that their plants were diseased attributed the trouble to the common or *Phytophthora* blight. In order to aid in distinguishing these diseases, we issued a circular Aug. 12th, 1892, describing the two. So far as we have learned, it served its purpose well.

Potato growers generally have used the terms "blight" and "rust" for any disease of the potato-leaves. In our descriptions we have found the terms "early blight" and "late blight" very helpful. It would be better if we could re-name these diseases to apply the name "potato-mildew" to the *Phytophthora* disease, and the name "leaf-spot disease" to the *Macrosporium*. An attempt to introduce these as popular names would, however, only lead to confusion. The terms "early blight" and "late blight" as we use them, also describe the diseases as they occur in Canada, according to Prof. Fletcher, and we think they will serve as well in all northern New England and New York, as in Vermont. Further South and West there appears to be little of the *Phytophthora* blight.

In our popular descriptions of the two diseases, we have emphasized the following points of difference:

1. *The dates* of the attack, already mentioned.

2. *The weather.* The early blight developing and spreading even in dry, cool weather, the late blight only in warm, moist weather.

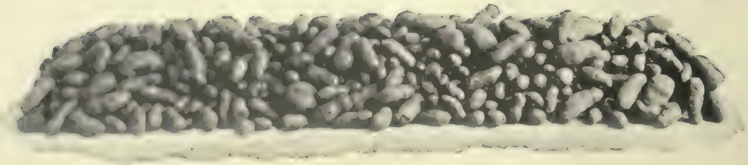
3. *The rapidity of the spread.* The early blight slowly, the late blight very rapidly.

4. *The appearance.* In order to show more clearly the more striking differences in the appearance of the two diseases we have inserted two drawings Fig. 1 and Pl. IV. Fig. 1 is from a plate in the Report of U. S. Dept. Agric. for 1888, and shows the mode of attack of the *Phytophthora* or late blight. Plate IV shows a leaf attacked by the *Macrosporium* or early blight.

The *Phytophthora* or late blight appears on the leaf as a purplish black spot, which rapidly increases in size until it spreads over the entire leaf. As shown in Fig. 1, the diseased spot may start anywhere upon the leaf, and once started it spreads so rapidly that the base of a leaf is often black and dead, while the tip is still green, not having had time to wilt

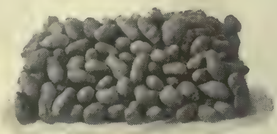
PLATE I.

1 Untreated. 2 Copper-Soda Solution. 3 Verdigris Solution. 4 Bordeaux Mixture & Molasses.
5 Ammoniacal Copper Carb. 6 Untreated. 7 Strong Bordeaux Mixture. 8 Weak Bordeaux Mixture.
9 Very weak Bordeaux Mixture. 10 Copper and Amm. Carb. 11 Untreated. 12 Glue Mixture.
13 Modified Eau Celeste. 14 Copper Carbonate. 15 Copper Chloride. 16 Untreated.



PLOT 4.

Total marketable tubers, 354½ bu. per acre.



PLOT 5.

Total marketable tubers, 105½ bu. per acre.

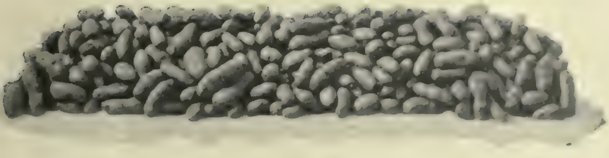
PLOT 4.

Bordeaux Mixture and Molasses.

PLOT 5.

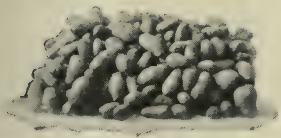
Ammoniacal Copper Carbonate.

PLATE III.



PLOT 7.

Total marketable tubers, [redacted] bu. per acre.
291



PLOT 6.

Total marketable tubers, 99½ bu. per acre.

PLOT 6.
Untreated.

PLOT 7.
Bordeaux Mixture.

THE EARLY BLIGHT OF POTATOES.

Macrosporium Solani, E. & M.

FIG. I.

THE LATE BLIGHT OF POTATOES.

Phytophthora infestans, D. By.

This is the case in the lower right hand leaf of Fig. 1. For the same reason, if the disease appears at the tip of the leaf, as shown in the lower left hand leaf in Fig. 1, it may spread over the entire leaf before there is time for the natural drying and curling up of the dead portion.

The general appearance of the leaves attacked by the early blight is shown in Plate IV. In contrast with the single large spots of the late blight we have here many small spots scattered over the leaves, as shown on the lower leaves. These spots gradually enlarge and merge together, as shown on the upper leaves. The tips and edges of the leaf are especially attacked ; as are also places where flea-beetles or other insects have mutilated the leaf. The progress of the early blight is comparatively slow. Owing to this slow progress and to the drier weather, the diseased portions of the leaf dry and become crisp as fast as they die, and the dead tips and edges of the leaves curl up, as shown in the upper leaves. No such mildew as occurs on leaves suffering from the late blight is ever found about these

dead spots, but a careful examination does show peculiar and characteristic marks. These are faint, thickened lines or rings in the dead spots, one ring outside the other, like the rings on a target board.

The two diseases may be contrasted as follows: .

EARLY BLIGHT.	LATE BLIGHT.
1. Apparently a "new disease" economically.	1. Has been common for 50 years or more.
2. Attacks early potatoes. Worst in July.	2. Attacks medium and late potatoes. Worst in August.
3. Progresses slowly. Not checked by dry, cool weather.	3. Progresses very rapidly, and only during the moist, warm weather.
4, Shows as several or many small dead spots (slowly enlarging and merging together later) scattered over the leaf. Leaf often dies at tip and edges first.	4. Shows anywhere upon the leaf, generally as a single spot which rapidly spreads over the whole leaf.
5. Owing to slow progress and dry weather the dead portions dry, crisp and curl up, especially at the tips and edges of the leaf.	5. Owing to the rapid progress and wet weather, the diseased leaf does not usually have time to dry and curl until the entire leaf is dead.
6. Caused in part by the fungus, *Macrosporium Solani.*	6. Caused by the fungus *Phytophthora infestans.*
7. Which causes peculiar "target board" markings in the dead spots.	7. Which can often be seen as a delicate frost-like mildew.
8. Disease is confined to the tops. No rotting of the tubers.	8. Disease passes from leaves to tubers, causing "rot."
9. The loss is therefore such as results from premature death of the vines.	9. The loss is therefore two-fold: (a) Premature death of vines. (b) Rotting of tubers.
10. Can probably be checked by applying Bordeaux Mixture three to five times, beginning (on early potatoes) early in July.	10. Both blight of tops and rot of tubers can be prevented by two or three applications of Bordeaux Mixture, beginning generally the latter part of July.

In so far as this early blight is caused by the attacks of the *Macrosporium*, we may hope to hold it in check by spraying, as for the other blight except that we must begin earlier, the first to the middle of July on early potatoes. From the results so far obtained at other Stations, as well as in our own work, we do not think this early blight will succumb as readily to the Bordeaux Mixture as has the late blight. This is a matter which will be further tested at this Station, and doubtless at others, for the same disease seems to be general in this country and in Canada.

But even granting that we can check this early blight on our early potatoes, the number of applications and the consequent trouble and expense must be greater than that of checking the late blight on later planted potatoes. *We believe therefore that for our main potato crop in Vermout the better way is to plant later, say the middle of May. We can thus largely if not entirely escape the early blight, and by spraying only two or three times in August we can secure a large crop free from blight or rot.*

(c) POTATO SCAB.

A test was undertaken of several methods of treating seed potatoes for the prevention of Scab. The methods used were suggested by the results of the work of Professor Bolley of the N. Dakota Station (described in Vt. Bul. 28, p. 29), and of Prof. Kinney of the Rhode Island Station (R. I. Bul. 14). The seed used was all of the "White Star" variety, cut to two eyes. That used in Plots 1-4 was extremely scabby. The method of disinfection in plots 2, 3 and 4, was soaking 1½ hours in 1:1000 corrosive sublimate solution. The ground prepared for the test was a clay sod which had been in grass for at least seven years. It was, however, open to the objection of having poor and uneven drainage, and sloped so that water might drain from one plot to another in many places. The unsatisfactory results of the experiment may in part be due to this.

The plan of the experiment with the results is shown in the table on the next page. These results evidentlyallow of no conclusions relative to the disease; they simply add another to the many perplexing outcomes of Scab experiments conducted on our long cultivated New England soils.

The results in the cases of plots 3 and 4 are of some interest, as showing that the tubers should be disinfected before cutting. The evil effects of disinfecting after cutting, are probably greater here than they would have been had more vigorous seed been used, the "scabby" seed being of low vitality anyway.

The amount of Scab in all parts of the field was surprisingly small,none of the tubers being so scabby as to make them unmarketable, whereas the scabby seed was from a field of which the entire crop was unmarketable because of the disease.

TABULATED RESULTS OF SCAB EXPERIMENT.

No. of Plot.	Kind of "Seed."	Treatment of Seed.	No. of Pieces Planted.	No of Hills Dug.	Per cent of the Pieces Planted that Grew.	Large Tubers Smooth.		Large Tubers Slightly Scabby.		No. of Small Tubers Smooth.	No. of Small Tubers Slightly Scabby.
						No.	Wt. lbs.	No.	Wt. lbs.		
1	Scabby.	None	132	112	85	326	$75\frac{1}{4}$	35	9	198	25
2	"	Washed, then disinfected, then cut	127	115	90	250	$68\frac{7}{8}$	97	$22\frac{7}{8}$	102	23
3	"	Washed, then cut, then disinfected	132	52	40	127	$45\frac{1}{2}$	0	0	29	0
4	"	Cut, then disinfected (not washed)	132	93	70	262	$73\frac{1}{8}$	6	$1\frac{3}{4}$	66	2
5	"	(a) Sprayed with Bordeaux Mixture in furrow	66	64	97	154	$40\frac{1}{4}$	18	$4\frac{1}{8}$	42	8
		(b) Soaked ½ hour in Bord. Mix.	66	62	94	208	$48\frac{3}{4}$	7	$1\frac{7}{8}$	89	6
6	Smooth.	Placed manure in furrow, dropped "seed" on this, then sprayed as in 5a	132	115	87	327	$81\frac{3}{4}$	54	$14\frac{3}{8}$	99	15
7	"	Untreated, check of 6	132	121	91	338	$84\frac{3}{4}$	85	$19\frac{5}{8}$.	75	30

II. OAT SMUT.

(a) A Further Experiment with Remedies.
(b) Effect of Hot Water Treatment upon Germination and Yield.
(c) Loss from Smut in Vermont, and Relation of this loss to the source of the Seed used.

(a) FURTHER EXPERIMENT WITH REMEDIES.

The tests begun last year* were continued during the present season. Two general methods of treatments were tried: the hot water treatment and soaking in solutions of potassium sulphide. Very smutty seed was used, as is evident from plots 1 and 11.

Plot.	Treatment of Seed.	Per cent of Smut in Crop.
1	Untreated	17.2
2	Soaked at 125° F. 5 minutes	5.6
3	" 128° F. 15 "	0.
4	" 130° F. 15 "	0.
5	" 133° F. 15 " then dipped in cold water	0.
6	" 133° 10 minutes	0.
7	" 138° 5 "	.6
8	" 143° 5 "	.8
9	" in 1 per cent Sol. Potassium Sulphide 12 hours	.65
10	" ½ " " " " 24 "	3.
11	Untreated.	15.8

These results confirm those of last year, and agree with those obtained by all other experimenters as to the efficacy of the various hot water treatments. So far as their fungicidal value is concerned, either the longer treatment at the lower temperatures or the shorter time at high temperatures, gives practical freedom from smut. The small amount of smut found in plots 7 and 8, suggests that in these shorter treatments at high temperatures, care needs be taken to keep the grain stirred so that all is heated through.

The potassium sulphide treatments of plots 9 and 10 are those suggested in "Farmer's Bulletin No. 5," of the U. S. Department of Agriculture.

In this experiment, the ½ per cent solution 24 hours, did not prove effective, but the 1 per cent solution 12 hours, gave good results.

*Vt. Rep. 1891, p. 135.

(b) EFFECT OF THESE TREATMENTS UPON GERMINATION AND YIELD.

The possible benefits from the soaking of seed oats in hot water aside from the destruction of the smut spores, have been the subject of investigations, especially at the Kansas and Indiana Stations. Careful and repeated experiments there have led to the conclusion that there is an indirect gain in the yield, that is a gain over and above that due to the destruction of the visible smut. This gain has amounted to 10 per cent, and even more in some cases. The testing of this question was a matter of more interest to us last summer, than was the question of the fungicidal value of there treatments.

Two plots were carefully prepared for the test. The seed used was of "Canadian" stock that had been grown on the farm the year before, when it contained 3 per cent of smut. This season there was less than 2 per cent. of smut in the untreated, and none, of course, in the treated plots. The seed was sown with drill, 2 bushels per acre, April 23. Everything was favorable and a magnificent stand of grain was the result, until about the time it headed out, when it rusted badly and did not fill well. From germination until harvest there was no appreciable difference in favor of either treated or untreated plots, unless it was a very slightly thicker stand on the untreated. This, however, was hardly perceptible.

The arrangement of plots, treatments and yields were as follows:

SERIES A. EACH PLOT 10½ X 276 FEET.

Plot 1.	Untreated. Yield, 111 lbs. grain, 205 lbs. straw and chaff.
Plot 2.	Soaked in water at 143°, 5 minutes, then dipped in cold water. Yield, 104 lbs. grain, 241 lbs. straw and chaff.
Plot 3.	Soaked in water at 138°, 5 minutes. Yield, 101 lbs. grain, 235 lbs. straw and chaff.
Plot 4.	Untreated. Yield, 109 lbs. grain, 241 lbs. straw and chaff.
Plot 5.	Soaked in water at 133°, 10 minutes. Yield, 101 lbs. grain, 279 lbs. straw and chaff.
Plot 6.	Soaked in water at 133°, 15 minutes, then dipped in cold water. Yield, 94 lbs. grain, 252 lbs. straw and chaff.
Plot 7.	Untreated. Yield 111 lbs. grain, 261 lbs. straw and chaff.
Plot 8.	Soaked in water at 143°, 5 minutes, then dipped in cold water. Yield, 101 lbs. grain, 261 lbs. straw and chaff.
Plot 9.	Soaked in water at 138°, 5 minutes. Yield, 103 lbs. grain, 247 lbs. straw and chaff.
Plot 10.	Soaked in water at 133°. 10 minutes. Yield, 101 lbs. grain, 253 lbs. straw and chaff.
Plot 11.	Soaked in water at 133°, 15 minutes, then dipped in cold water. Yield, 98 lbs. grain, 199 lbs. straw and chaff.
Plot 12.	Untreated. Yield, 102 lbs. grain, 209 lbs. straw and chaff.

SERIES B. EACH PLOT 6 X 150 FEET.

Plot 1.	Untreated. Yield, 37 lbs. grain, 144 lbs. straw and chaff.
Plot 2.	Soaked in water at 143°, 5 minutes, then dipped in cold water. Yield, 27 lbs. grain, 144 lbs. straw and chaff.
Plot 3.	Soaked in water at 138°, 5 minutes. Yield, 38 lbs. grain, 173 lbs. straw and chaff.
Plot 4.	Soaked in water at 133°, 15 minutes, then dipped in cold water. Yield, 35 lbs. grain, 150 lbs. straw and chaff.
Plot 5.	Soaked in water at 133°, 10 minutes. Yield, 26 lbs. grain, 141 lbs. straw and chaff.

We can find in these figures no evidence of great gain or loss from the treatments. So far as there is any difference, however, it shows a little more grain from the untreated plots and a little more straw from the treated plots. The following are the averages:

SERIES A.

Untreated: Grain, 108.2 lbs.
Straw and chaff, 226.7 lbs.
Treated: Grain, 100.4 lbs.
Straw and chaff, 232.2 lbs.

SERIES B.

Untreated: Grain, 37 lbs.
Straw and chaff, 144 lbs.
Treated: Grain, 31 lbs.
Straw and chaff, 152 lbs.

AVERAGE GAINS SERIES A AND B.

Grain, 10 per cent. more from untreated.
Straw and chaff, 3 per cent, more from treated.

These results do not agree with those of Dr. Kellerman, Dr. Arthur or Dr. Jensen. Since these men are all careful and experienced experimenters there can be no doubt as to the correctness of their conclusions, viz., that under the conditions of their experiments there was a marked increase of yield from the hot water treatment. This hot water treatment, in Dr. Arthur's experiments and likewise in our own, has hastened the

germination of the grain, even though it is thoroughly dried after the treatment and before planting. At the same time, in our own tests, it has lowered the per cent. of actual germination of the oats. But Dr. Arthur's (1) and Dr. Kellerman's (2) published results show this same fact. Dr. Arthur considers the action of the hot water in thus hastening germination and increasing the yield, to be due to the development of a ferment which "renders an unusual amount of starch available at the outset" (3). Dr. Kellerman advocates that part, at least, of the increased yield is due to the destruction of what he terms "concealed smut," or to the destruction of smut which, though it does not fully develop, yet injures the grain (4). We have found none of this "concealed smut" in our fields, and in a number of samples sent Dr. Kellerman, he found none of it. According to Dr. Kellerman's explanation, therefore, it would seem that we have no right to expect the same gain from the hot-water treatment that he found.

Granting that the per cent. of germination is lowered in the treated seed, then this must have some effect upon the yield. Experiments as to the amount of oats to be sown per acre at the Ohio and Indiana Stations, have shown that in general they get the maximum yield from about two bushels of seed per acre, sown by drill, and from about two and one-half bushels sown broadcast. More or less than this amount decreases the yield. On supposition that more than two and one-half bushels were sown per acre,the hot water treatment would tend to increase the yield merely from the fact that it lessens the per cent of germination; for the same reason if less than two bushels per acre were sown the hot water treatment would tend to lessen the yield. Opposed to this tendency in the latter case, and in co-operation with it in the former case, we have the beneficial effects of the hot water in increasing the solubility of the starch in the treated seed.

Again, it seems probable that the effect of the hot water in lowering germination is greater in some oats than in others. A marked difference in the effect of this treatment upon seed-corn, was noted in our tests in 1891 (See Ann. Rep. 1891, p. 140).

From our results, therefore, we feel compelled to doubt that the hot water treatment will in all cases increase the yields of oats, and to believe instead that in some cases it will actually decrease the yield.

(c) AMOUNT OF THE LOSS FROM OAT SMUT IN VERMONT AND THE RELATION OF THIS LOSS TO THE SOURCE OF THE SEED.

July 5, 1892, a copy of the following request was sent to each of one-hundred farmers in the State:

1. Agricultural Science, Sept. 1892.
2. Proc. A. A. A. S., 1892, p. 213.
3. " " " p. 227.
4. Kas. Exp. Sta. Bull. 15, p. 127.

STATE AGRICULTURAL EXPERIMENT STATION,
BURLINGTON, VT., July 5, 1892.

Dear Sir :—Since we now have a sure remedy for oat smut in the proper use of hot water for disinfecting the seed oats, it becomes a matter of importance to learn whether there is enough smut in the oat fields of the State generally, to make the use of this remedy profitable. Careful examination of an oat field almost invariably shows that there is more smut than is commonly supposed. Still it is a question whether there is enough smut as a rule to pay for the trouble of disinfecting the seed. In order to gain as much information as I can upon this point, I wish to get samples of grain from a large number of the oat fields of the State. These samples will be carefully examined, the relative amount of smut in each determined and a detailed report of the results made later. The result of so large a number of examinations cannot but prove instructive. Will you aid me in this work by sending samples from at least one oat field. If you can send samples from several different fields (that is fields sown with seed from different sources), I shall be very glad to receive them. In order to insure uniformity in method, as well as impartiality, the following directions are given for taking the samples :

1. The samples should be taken as soon as fully headed out.

2. As the disease is liable to be somewhat unevenly distributed at least five samples should be taken from each field.

3. That the samples may be of uniform size, take a heavy barrel hoop or make a frame about 2 feet square by tacking together four pieces of lath. In taking the samples drop this hoop or frame down over the grain and cut all of the plants enclosed by it close to the ground. Tie a string around each sample as soon as cut. Take five samples in this way from different portions of the field. Tie all into a bundle, wrap in several newspapers, or some old sacking, and send by express. A shipping tag properly addressed is enclosed.

If for any reason you cannot furnish the samples, will you kindly send me on the enclosed card the name of some one in your town who would, in your opinion, take the samples with proper care.

Yours sincerely,

L. R. JONES.

In reply to these requests, eighty-one samples were received, from as many oat fields. Upon examining these samples it was noticed that in most cases where the history of the seed was given there was more smut in grain from Western seed than in that from Vermont seed. In order to investigate this matter more fully, a second letter was sent to each one who sent samples, asking the source of the seed oats in the field from which the sample was taken. The results are interesting and instructive, as will be seen from the following summary. In order to show the results more clearly

the samples are arranged in the order of their smuttiness, and are placed in three tables, according to source of seed:

TABLE I—VERMONT SEED.

No.	Name.	Address.	Sound.	Smutty.	Per cent.	Remarks concerning seed.
75d	A. J. Hazen	Alburgh	566	38	6.29	From West 1868.
100	J. W. Wright	Pownal	267	15	5.62	From L. I. 1870.
96	E. R Pember	Wells	439	20	4.35	Vt. grown for 20 years.
59	G. G. Hinsdale	St. George	477	16	3.24	" " " several years.
77c	F. G. Richardson	Brookfield	264	7	2.88	Same strain for 21 years.
75a	T. D. Jameson	Alburgh	445	10	2.19	Home grown several years.
6	W. Richmond	Newport	596	13	2.13	Same farm 20 years.
111	Lewis Talcott	Williston	346	7	1.98	Seed from Grand Isle Co.
77b	Monroe Wheatly	Brookfield	280	5	1.75	Vt grown for 10 yrs or more
13	Crosby Miller	Pomfret	133	2	1.48	From Dept. Ag. 12 yrs. ago.
72c	Benson Sanborn	S. Royalton	347	4	1.13	Home grown several years.
3	O. F. Stearns	Windham	305	3	.97	Vt grown seed 10 yrs or more
76b	H. J. Parker	Andover	320	3	.92	" " " great many yrs
	J. F. Hemenway	E. Chelsea	238	2	.83	Same town for years.
12	Cassius Peck	Brookfield	370	3	.79	Home grown over 20 years.
10 d	E. Stevens	Jonesville	382	3	.77	Vt grown for 6–8 yrs at least
75c	W. T. Sowles	Alburgh	419	3	.71	Same seed used grt many yrs
57	Henry Lawrence	St. George	299	2	.66	Vt. grown for long time.
72a	C. P. Stevens	Chelsea	453	3	.65	From West several yrs ago.
62c	J. W. Millards	Stamford	469	3	.64	Vermont seed.
93a	L. S. Chaffee	Troy	622	4	.64	" grown several yrs at least
4	E. R. Towle	Enosbgh Flls	556	3	.53	Same seed used for yrs.
54a	G. B. Brewster	Irasburgh	574	3	.52	" " " 20 yrs or more
63	W. H. Small	Morrisville	376	2	.52	Vt seed far back as can trace
54c	David Webster	Irasburgh	423	2	.48	Same seed used many years.
10b	B. S. Balch	Jonesville	233	1	.43	Home grwn 10-12 yrs at least
107	N. E. & J. Miller	Burlington	239	1	.42	Vt seed for sevral yrs at least
73	E. A. Edson	Chester	235	1	.41	Same seed several years.
70	Julius Morse	Cambridge	793	3	.38	Home grown grt. many yrs.
8	M. V. Willard	Jericho Cent	853	2	.36	Same seed used 10–12 years.
40	A. Messer	Rochester	307	1	.32	Vt grown several yrs at least
10c	Albert Town	Jonesville	322	1	.31	Vt seed, as far as can trace.
78	W. G. McAllister	Waitsfield	671	2	.29	From England 8 years ago.
69	A. M. Foster	Cabot	392	1	.25	Home grown grt. many yrs.
32	M. V. Clark	N. Williston	453	1	.22	Home grwn sevl yrs at least
54b	D. C. Carpenter	Irasburgh	586	1	.18	Vermont seed.
10a	S. Whitcomb	Jonesville	375	0	.00	Home grwn sevl yrs at least
39	P. K. Spaulding	Proctorsville	181	0	.00	Vt. seed as far as can trace.
44	L. W. Peet	Cornwall	386	0	.00	From U. S. Dep. 12 yrs ago.
72b	Milo Sanborn	Chelsea	354	0	.00	Vt. seed as far as can trace.
77	T. H. Wheatley	Brookfield	349	0	.00	Home grown seed.
84	D. R. Pierce	Waterville	309	0	.00	Seed raised in neighborhood as far back as can trace.
84b	R. W. Leach	"	157	0	.00	
84c	Mr. Olin	"	220	0	.00	
95	J. S. Wheeler	Waterbury Center	430	0	.00	Same seed 57 years. "No change, No mixing."
104a	Mr. Kennedy	Underhill	168	0	.00	Vermont grown several years at least.
104b	M. Chapin	"	166	0	.00	

Number of heads examined .... 18,375.
Average per cent. of smut found .... 1.00.

TABLE II. WESTERN SEED.

No.	Name.	Address.	Sound	Smut.	Per Cent.	Remarks.
65a	O. L. Miner	Brattleboro	335	25	7.44	Western, from feed store.
65b	"	"	73	14	5.79	" " " "
6	E. B. True	Newport	249	30	4.96	From West, 1891.
62II	Walter Brattan	Stamford	492	20	4.07	Western, from feed store.
87	A. A. Storrs	E. Bethel	656	27	3.93	Western, from E. W. Bailey, Montpelier.
91	G. S. Worcester	Thetford	263	14	3.61	Western seed.
28	LeRoy Southw'th	Middletown Springs	384	14	3.60	Western, from S. B. Curtis, Rutland.
1	Alonzo Emery	W. Rand'lph	375	14	3.59	From West, 1891.
64	G. H. Parker	Proctorsville	389	14	3.47	Western seed.
62I	Fred Foster	Stamford	313	10	3.20	From West 2 years before.
75b	Lewis Furrier	Alburgh	524	15	2.96	Mixed Western seed.
76I	A. J. Parker	Andover	235	7	2.89	Western seed, 4 years ago.
19	C. C. Forbes	Shoreham	948	26	2.66	Seed from Illinois, 1885.
27	J. C Sherburne	N. Pomfret	873	19	2.13	Western, from grain dealer.
65c	O. L. Miner	Brattleboro	72	1	1.40	" " " "
43	E. N. Cleveland	Franklin	1048	8	.66	Seed from Ia., 1886.
104c	Mr. Hale	Underhill	152	1	.65	From West, 1890.
93II	L. S. Chaffee	Troy	1059	6	.50	Western seed.
92	J. B. McLain	Topsham	394	2	.50	" "
74	J. E. Chamberlin	Bt. Landing	410	1	.24	" "

Number of heads examined 9,481
Average per cent of smut found 3.13

TABLE III. SEED FROM OTHER, OR FROM UNKNOWN SOURCES.

No.	Name.	Address.	Sound.	Smut.	Per Cent.	Remarks.
100	C. F. Johnson	Williston	195	1	5.62	Source unknown.
108	Irving Whitcomb	"	1266	28	3.32	" "
9	C. C. Haynes	Wilmington	202	6	2.88	" "
110	John Whitcomb	Williston	349	12	2.00	" "
22	V. I. Spear	Braintree	400	8	1.98	From dealer, source unkn'n.
103	W. Houghton	Lyndon	668	6	.88	From Dep. Ag. 3 yrs. ago.
6	F. Wheelock	Derby	797	7	.87	From Manitoba 3 yrs. ago.
112	C. Miller & Sons	Williston	572	4	.69	Source unknown.
106	C. F. Johnson	"	195	1	.51	" "
90	E. B. Batchelder	Townshend	611	3	.50	" "
113	Samuel Bliss	Essex	514	2	.38	Source unknown.
79	E. A. Fitch	Wilmington	261	1	.34	From N.Y., 3 yrs. ago.
109	C. Caswell	Williston	495	1	.20	Source unknown.
45	Dwight Sykes	Dorset	259	0	.0	From N. Y. 2 yrs. ago.
105	Harry Fay	N. Williston	457	0	.0	" " ?

Number of heads examined 7,321
Average per cent of smut found 1.34

From Tables I, II and III we have

Total number of heads examined..........................35,177

Average per cent of smut found in all samples.................1.6

These results allow of two conclusions. the first of which may be overruled by further examinations and experiments; the second appears to be final. They are:

First—In general the loss from oat-smut in this State, where native seed is used, is not large enough to demand the use of the hot water or other treatment for disinfecting the seed.

Second—The average loss from oat-smut, where Western seed is used is much greater than where native seed is used, being in the samples examined over three times as great.

As stated in formed publications, oat-smut is a disease propagated almost entirely in the seed-oats The force of this last conclusion is therefore increased by a comparison of the amounts of smut found by Westen investigators with that reported above. The loss from oat-smut as determined at the New York State[1] Experiment Station (1884-1886) was 9 per cent of the crop. In Kansas[2] (1888-91), the loss was placed at 10 per cent; in Indiana[3] (1891), at 10 per cent; in Michigan[4] (1891), 15 per cent; in Wisconsin[5] (1891), the total loss is placed as greater than that of Michigan.

In view of these estimates the U. S. Dept. of Agriculture in a recent bulletin[6] states that "the average loss is from 5 to 12 per cent in different localities in the United States," while Dr. J. C. Arthur,[7] in a recent article states that this country loses annually from smut "nearly or quite 10 per cent of the total oat crop."

In order to satisfy ourselves as to the absence of any "concealed" smut which we might have overlooked in our examinations, we sent a number of the above samples to Dr. W. A. Kellerman of Columbus, Ohio, a recognized authority on oat-smuts, who after kindly examining them wrote: "I have carefully examined the bundles of oats sent me—over four thousand heads—and do not find any more smutted heads than you have found. I did not see any 'concealed' smut, though I handled each head separately and examined carefully."

In conclusion, it must be observed that the amount of smut in the same strain of oats, may vary considerably from year to year. Some facts would indicate that the amount of smut about Burlington was rather less in 1892

1, 3d An. Rep. N. Y. Ag. Exp. Sta. p. 382 and 5th Rep. same p. 124.

2, 2d An. Rep. Kas. Ag. Exp. Sta. p. 226.

3 Indiana Exp. Sta. Bul. 35, p. 81.

4 Mich. Exp. Sta. Bul. 87, p. 3.

5 Wis. Exp. Sta. Bul. 34, p. 4.

6 Farmers' Bul, 5, p. 4.

7 Agricultural Science, Sept., 1892.

than in 1891, yet we do not think the difference was very great. In order, therefore, to reach conclusions of permanent value as to the actual loss from smut, it is necessary to make such examinations for more than one year, and it is proposed to repeat this work the coming summer.

III. ORCHARD DISEASES.

(a) APPLE SCAB.

Some experimental work in checking apple-scab was undertaken. Owing, however, to the excessive rainfall of June and July the results were not satisfactory, as the increase of crop in the larger experiment was not sufficient to pay for the cost of the work.

In a small orchard near Burlington, two Fameuse trees were sprayed, and two standing beside them left as checks. The dates and applications were as follows:

May 3: Copper Sulphate Solution (1 lb. in 10 gals. water.)

June 15: Bordeaux Mixture (and Paris green), (5 lbs. Blue Vitriol, 5 lbs. lime, 50 gals. water.)

July 1: Ammoniacal Copper Carbonate (5 ozs. copper carbonate, 3 pints ammonia, 45 gals water.)

July 25: Ammoniacal Copper Carbonate.

When picked the saleable apples were sorted into number ones and number twos, as follows:

Tree No. 1, Sprayed:—	No. 1, 463	apples;	wt.	55 lbs.
	No. 2, 457	"	"	54 "
Tree No. 2, Sprayed:—	No. 1, 307	"	"	38 "
	No. 2, 411	"	"	42 "
Tree No. 3 Check:—	No. 1, 384	"	"	55 "
	No. 2, 696	"	"	72 "
Tree No. 4, Check—	No. 1, 280	"	"	37 "
	No. 2, 411	"	"	44 "

These results may be more easily compared in the following form:

		NUMBER.		WEIGHT.	
			Per Cent.	lbs.	Per Cent.
Sprayed Trees........	No. Ones...	770	47	93	49
" "	No. Twos...	868	53	96	51
Check Trees..........	No. Ones...	664	37½	92	44
" "	No. Twos...	1107	62½	116	56

Experimental work on a much larger scale was carried on in the orchard of Mr. T. L. Kinney of South Hero. Mr. Kinney's orchard is admirably situated for experimental work. The trees are in fine condition, but several varieties of the apples suffer much from the scab, as in all

orchards near the lake. The north half of the orchard was divided into three plots, upon which it was planned to test the relative merits of ammoniacal copper carbonate, modified eau celeste and weak Bordeaux mixture. We also hoped to test the practical gain from spraying on a larger scale than we have heretofore been able to do in our orchard work. The rains of June and July were so incessant, however, as both to prevent spraying when it should have been done and to wash off the mixtures soon after they were applied. As a result there was no appreciable benefit from the spraying that was done.

The work was done with a Field force pump having two discharges, to each of which was fitted twelve feet of ⅝-inch hose. To one of these we fitted a ten-foot piece of ½-inch gas pipe, carrying a Vermorrel nozzle at the end. To the other hose we attached twelve feet of ½-inch rubber tubing, also fitted with a Vermorrel nozzle. To elevate this into the trees we used a ten-foot bamboo fish pole. We liked the latter arrangement rather better than the former, but the gas-pipe is cheaper and more durable than the light hose, and would prove the more practical device for most orchardists. With this pump, when it was in good working order, three men and a team applied at the rate of 300 to 400 gallons per day (of ten hours) preparing their own mixtures. It took about two gallons of the mixture to cover an average sized tree.

(b) BROWN SPOT DISEASE OF APPLE LEAVES.

The apple leaves in Mr. Kinney's orchard, and also in various orchards examined near Burlington, were quite seriously attacked by the Brown Spot Disease, caused by the fungus *Phyllosticta pirina*, *Sacc.* This was first noticed in Mr. Kinney's orchard July 6th, as circular brown spots, varying in size from a shot to a pea, and scattered irregularly over the leaves. From this time on during August the spots increased in number and size. The same trouble was reported to us by Mr. A. J. Grout from Newfane, Vt. The unusual amount of this disease last summer was probably due to the wet weather.

(c) APPLE-RUST AND CEDAR APPLES.

For the past two years we have tested the results of spraying apple trees to check the rust (*Roestelia pirata*, *Thaxter*), which is another stage of the cedar-apple fungus (*Gymnosporangium macropus*, Lk.), on the common red cedar. As stated in our last report (Rep. 1891, p. 133), spraying, although beneficial, did not entirely check the rust so long as the cedar trees were left in the orchard. In the fall and winter of 1891-92 the red cedars were all destroyed in this orchard, and for a radius of one mile around careful examination was made, and every cedar found was uprooted. The result was magical. In former years many of the apple trees

were entirely defoliated by rust in August. This past summer not a rusted leaf was found in the entire orchard. The moral is plain. Red cedars should not be allowed to grow in or near an apple orchard. From the scientific standpoint the result is interesting as indicating that the mycelium of this fungus is not perennial in the apple, and that the occurrence of the rust on the apples is dependant upon annual reinfection from the red cedar.

IV. SPOT DISEASE OF CUCUMBERS.

(*Cladosporium cucumerinum, E. and A.*)

A peculiar and very destructive disease was found last summer in August and September, attacking both fruit and leaves of cucumbers. On the fruit diseased spots show when the fruit is small, as slightly sunken specks becoming larger with age until they are a quarter or a half-inch in diameter, meanwhile the fruiting threads of the fungus develop, forming a greenish-black velvety coating over the spot. The fungus was most common on the fruit, but was found also on the younger stems and leaves. It was first found in our garden upon "white spine" cucumbers, raised from seed obtained the year before from a New York firm. As the trouble had never been noticed by the market gardeners about here, to whom it was shown, we thought it might have been introduced with this seed, and that this was an isolated attack. In passing through the Burlington market in September, however, we noticed a large quantity of cucumbers which were entirely unsalable from the same disease. They were from the farm of Mr. L. A. Drew. Mr. Drew had never noticed this disease before, and said that the trouble did not attract his attention much in this field this season, most of the spots having appeared after the fruit was marketed. These two outbreaks of the trouble would indicate that it is not a new disease in this section, but that in most seasons its attacks are so slight as to attract little or no attention. Its unusual virulence this past fall was probably due to the warm wet weather of August, the same conditions which aggravated the potato blight. We shall be glad to have any gardeners who notice this disease in the future, write us of the fact.

This disease was first noticed at the Geneva, N. Y. Experiment Station, by Dr. J. C. Arthur in 1887, where "it was so abundant as to ruin the crop for pickling."* No other mention of the occurrence of the disease has come to our notice.

V. GREEN-HOUSE DISEASES.

(a) LETTUCE ROTS.

In our report for 1891 (p. 141) mention was made of a lettuce-rot caused by the fungus *Botrytis vulgaris*. This same trouble again proved serious this winter (1892-3)

* Indiana Exp. Sta. Bul. 19.

Even more destructive, however, was another "rot" which may easily be confused with the *Botrytis* trouble, but which is an entirely different thing. In order to bring out more clearly the distinctions between the two, we have made two drawings which, though made from different varieties of lettuce, will help to bring out the characters of the maladies.

Fig. 2 shows a young plant of the Grand Rapids variety suffering from the attacks of the *Botrytis*. It will be noticed that the decay begins at the *base* of the *lower* leaves, where they are in contact with the soil, and proceeds from here upwards and outwards. In the plant in Fig. 2, the younger erect leaves at the heart are still free from disease, the location and degree of the rot being indicated by the shading on the lower leaves. The fungus forms a conspicuous dusty gray mould at the bases and along the midribs of the decaying leaves.

Fig. 3 shows a plant of the "Tennis Ball" variety, diseased in an entirely different way, yet this too is very properly spoken of by our market gardeners as "lettuce rot."

This trouble has been worse in the Experiment Station green-house on the head varieties, but has attacked all more or less seriously. As indicated in the drawing, the disease appears first at the *tips and edges* of the *inner* or heart leaves. Its distinction from the other trouble should therefore be easy. In the tender, moist leaves at the heart, the trouble first shows itself as a watery decay at or just inside the margin near the tip. This marginal portion often becoming limp. In leaves more exposed, the tissues blacken soon and become crisp as they die. The decay then passes backward, especially along the veins. This progress is generally rather slow, and as the leaves are growing very fast at this stage they become curled as shown in Fig. 3. Often a growth of the *Botrytis* appears upon these diseased leaves,hastening their decay, but this is a secondary attack and not the primary cause of the trouble. The characters of the disease suggest rather its bacterial nature primarily. The investigations of this matter are in progress, but are not, however, ready for publication.

Occurrence and Remedies.—From what we have seen and learned, we judge that both these troubles are common in lettuce houses. In our experience the *Botrytis* Rot has appeared to be aggravated by an excess of decaying matter, or of moisture in the soil. Precautions in preparing the bed and in watering are suggested, rather than the application of direct remedies. Pick off decaying leaves at the base of plants as soon as seen.

We have had little success in controlling the other rot, except in selecting varieties least liable to the disease.

We sent Mr. W. W. Rawson of Boston, a sample of this, asking what he knew as to its occurrence. We quote from his reply :

"The sample sent is a good type. I have seen lots of this trouble about Boston, not so much in my own houses as in others. The lettuce is all right

Fig. 2.

Fig 3.

until a certain stage of its growth, then it begins to rot in the heart. Some varieties are more susceptible than others. With proper handling I can keep it out, though I cannot even tell a man how, so that he can do it. I have to watch the house myself and then instruct the men what to do. The trouble is not caused by the sun, nor is it due to the high temperature; I consider the whole trouble of this rot at the heart to be caused by the dry air in the house at the time that it occurs, and I can run my houses so that there is no such trouble. It is very common, also, to see the rot around the stem [*Botrytis* rot]. This is due to the plant being in that condition when set out, and is caused by the improper conditions of the seed-bed."

A BACTERIAL "STEM ROT" OF LETTUCE.

While investigating these head-rots we found another trouble, the decay of the stem at or just below the surface of the ground. It was in the nature of a "damping-off," except that it occurred in the mature plant rather than the seedling. This decay was very rapid after it began, so that the head would lop over, with the stem completely decayed, before the rot reached the heart or leaves; in a few hours longer these too decayed. This disease is undoubtedly of a bacterial nature. The decaying tissues were found to be teeming with bacteria. One species, a large bacillus, was present apparently to the exclusion of other species in the less advanced stages of the disease. Pure cultures of this were obtained and when inocculated into the stem or heart of healthy plants it invariably led to the entire decay of the plant in from 18 to 48 hours, depending upon the conditions of the house as to temperature and moisture. This trouble probably does not occur often enough to cause serious loss in lettuce houses, though we have had described to us a peculiar "dropping down" disease, as occurring in some of the Boston houses, which seems similar to this trouble. We were perfectly satisfied that the bacillus found would cause this rot under favoring circumstances, providing it gained entrance to the stem. In order to test the danger of infection from soil containing the germs, a young lettuce plant was transplanted into each of four pots under the following conditions:

Pot 1. The decayed portions of a lettuce plant that had gone with the "stem rot" was mixed with the soil.

Pot 2. A decayed head was crushed in a little water and this water poured about the roots of the plant.

Pot 3. The pot was filled with soil taken from about the stem of a plant that had just decayed as the result of inocculation.

Pot 4. The pot was filled with soil taken from about the place where a plant had decayed a few days before.

Pot 5. This pot contained a young cucumber plant and was watered similarly to Pot 2.

Plants 1 to 4 all grew to maturity without any signs of the disease, until considering the experiment over, they were set aside under the shade of some other plants, where it was unusually moist and warm, when the stems of plants in pots 1 and 2 suddenly rotted off, and what was apparently the same bacillus was found swarming in the decaying tissues.

We conclude, therefore, that this "stem rot" is caused by a species of bacterium which may gain entrance from the soil, but is not to be fearedin case the house can be kept in proper condition as to heat and moisture. If it does occur, the diseased heads with surrounding soil should be at once removed from the house.

DAMPING OFF.

Some trouble was had in the green-house from "damping-off" of seedling plants, lettuce, balsams and pansies. Many such plants were examined and in all cases the trouble was found to be due to the fungus *Pythium DeBaryanum, Hesse.*

(b) A PECULIAR TOMATO TROUBLE.

The tomato plants in our green-house have suffered seriously this winter (1892-3) from a peculiar trouble. The most characteristic feature of the trouble is a curling downward of the edges of the leaflets, the veins of which are distorted and much swollen in places; yellow or light-colored spots on the leaves, dark-colored lines running lengthwise of the petioles and young branches and stems; the tissues along these lines eventually dying and in the stems often cracking open; fruit small and gnarly. Specimens of our plants were sent to Prof. G. F. Atkinson, of the N. Y. (Cornell) Station, who was investigating a trouble of the same nature in their houses. He pronounced the troubles identical, and I quote from his conclusions, based on a careful study of this "Oedema of the Tomato" (Bul. 53, Cornell Exp. Sta.) "The œdema of the tomato is a swelling of certain parts of the plant brought about by an excess of water which stretches the cell walls, making them very thin and the cells very large. The excess of water may be so great that the cell walls break down, and that part of the plant dying exerts an injurious effect on the adjacent parts. The excess of water in the tissues is favored by the following conditions:

1. Insufficient light. 2. Too much water in the soil. 3. The temperature of the soil may be too near that of the air."

In order to avoid the trouble, therefore, select well lighted parts of the house for tomato plants, give no more water than necessary, aim to have the temperature of the air considerably higher than that of the roots.

REPORT OF THE BOTANIST.

L. R. JONES.

The investigations of 1893 were a direct continuation of those of the previous year. Our experience is leading us to concentrate our attention more fully upon a few leading problems. Owing to the destructiveness of the potato diseases in Vermont, we believe that we can make our services of most value to the farmers of the State by giving that portion of our time which is not demanded by College duties to the study of these diseases and their remedies. When these problems are fully in hand we may push into other fields of investigation.

We wish here to thank one of our senior students, Mr. C. E. Stevens, for his valuable assistance in most of the experiments of this season.

The results of our work during 1893 will be found in this report under the following heads:

I. Experiments in Spraying Potatoes.

(A) Occurrence of the Diseases in 1893.

(B) Spraying Experiments.

1. The General Plan of the Field.
2. Fungicides Tested.
3. Results from Plot I.
4. Results from Plot II.
5. Results from Plot III.
6. Results from Plot IV.
7. Results from Plot V.
8. Potato Plots on the State Fair Grounds.
9. Effects of the Fungicides upon the Flea Beetle.
10. General Conclusions from these Experiments.

II. The Time and Rate of Growth of Potato Tubers, and the Effect of the Premature Death of the Potato Tops upon the Yield.

III. Relation of the Time of Planting Potatoes to the Diseases.

IV. A Spray Cart for Potatoes.

V. The Loss from Oat Smut in Vermont in 1893.

I. EXPERIMENTS IN SPRAYING POTATOES.

A. THE OCCURRENCE OF THE DISEASES IN 1893.

The Late Blight and Rot. Owing to our absence during the midsummer we are indebted to our assistant, Mr. C. E. Stevens, for most of the information upon this point. The late blight* was unusually late in developing. It caused little, if any, damage before September first, whereas, in 1892, it had ruined all of the unsprayed plants before August twentieth. As a result of this excep-

* *Phytophthora infestans* D. By.

tional length of life of the tops potato growers generally secured unusually large yields of tubers. Their loss from rot was, however, proportionally great, both in the field and in the cellar. The beneficial effects from spraying potatoes in 1893 were therefore more largely due to the checking of this rot than was the case in 1892, or in any other year since 1888. We are able to form a close estimate of the relative losses in the two years (1892 and 1893), from the premature death of the vines and from the rotting of the tubers, by comparing Plot V. of 1893 with our main field of 1892.

1892, *White Star Potatoes planted May* 15, *blight appeared Aug.* 10.*

Sprayed plot:	marketable tubers,	291¼ bu. per A.	rotten tubers,	2 bu. per A.
Unsprayed plot:	"	99½ "	"	24¾ "

The total gain from spraying was 192 bushels per acre, of which but 23 bushels per acre, or one-eighth, came from checking the rot. Clearly the difference, 169 bushels, was produced by the prolonged life of the vines.

1893, *White Star Potatoes*,† *planted May* 20, *blight appeared September* 1.

Sprayed rows:	marketable tubers,	375 bu. per A.	rotten tubers,	23.6 bu. per A.
Unsprayed rows:	"	121 "	"	149.6 "

The total gain in 1893 from spraying these rows was 254 bushels per acre, of which 126 bushels, or one-half, came from checking the rot and 128 bushels came from the prolonged life of the vines.

It is interesting to note in corroboration of these conclusions, that the table of yields from Plot VI. (See p. 54), shows the increase in yield of tubers of marketable size during the interval between September 1 and September 22 to have been about 120 bushels per acre.

The great loss from rot in 1893 was partly due to the fact that the tubers were much larger in September, 1893, when the disease was active, than they were in August, 1892, when the rotting took place. Part of the difference was doubtless due to the fact that the tops were killed less quickly in 1893, and consequently the discharge of the spores of the fungus upon the soil was continued for a much longer time.

The Early Blight. Owing to our absence we were unable to study further the cause and development of the disease we have described as the early blight. Our assistant states that it occurred again and caused serious trouble, especially on the earlier potatoes. In our last report‡ we discussed the probable causes of this trouble.

* See further details, 6th Rep. Vt. Exp. Sta., pp. 65-6.

† Averages of sprayed rows, 56 and 57 south and 68, 69 and 76 north. Averages of unsprayed rows, 55 and 58 south and 67, 69 and 77 north. See table VIII, pages 69 and 70.

‡ 6th Rep. Vt. Exp. St., pps. 66-8. Following are quotations from that Report: "We are still in some doubt as to the exact cause of this trouble (early blight) and do not think that any one thing is wholly responsible. Leaves that had been attacked by insects seemed to suffer most, many of the dead spots having at their center one or more of the holes eaten by flea-beetles. In many leaves examined we were unable to find any trace of fungus attack. In the majority, however, we found *Macrosporium Solani, E. & M.* We cannot say with certainty that this Macrosporium is the cause of the disease, yet the general association of the fungus with the disease leaves little doubt in our minds that it was the cause of at least a large part of the trouble last summer. Apparently insect punctures or other injuries to the leaves offer a favorable starting point for the fungus."

Examination of the preserved specimens of the diseased plants indicates that much of the trouble during July was caused by flea-beetles and drought. Leaves collected during August were badly spotted by the *Macrosporium* fungus, as illustrated in Plate IV. of our last report.

B. SPRAYING EXPERIMENTS.

(1) *The general plan of the field.*—In 1892, the experiments were conducted upon medium and late potatoes only. In the plots for 1893, both early and late varieties were used. These were planted at various dates in order to watch the development of, and to test remedies for the early blight as well as the late.

The following diagram shows the plan of the field, varieties used and dates of spraying:

PLAN OF EXPERIMENTAL POTATO FIELD, 1893.

PLOT I. Rows, 1–10. Polaris. Planted April 29.	PLOT II. Rows, 11–20. Burbank. Planted May 9.	PLOT III. Rows, 23–32 Polaris. Planted May 20.	PLOT IV. Rows, 33–42. Early Rose. Planted May 20. Sprayed twice. Aug. 1, 16.	PLOT V. Rows, 43–77. White Star. Planted May 20. Sprayed August 1, 16, 29.
This end sprayed twice. July 14, Aug. 1.	This end sprayed twice. Aug. 1, 15.	This end sprayed twice. Aug. 1, 15.		PLOT VI. Sprayed Aug. 1, 16, 29. Dug at different dates.
This end sprayed 3 times. June 16, July 14, Aug. 1.	This end sprayed 3 times. July 14, Aug. 1, 15.	This end sprayed 3 times. July 15, Aug. 1, 15.		

Size of field, 10x16 Rods. West + + East.

The potatoes were planted in hills two and one-half feet apart. The rows ran north and south three feet apart. The soil was an old garden, sandy loam, and was given a uniform dressing of commercial fertilizer. In order to test the relative values of two and of three applications, the south half of each row in Plots I, II and III, was sprayed three times, while the north half was sprayed only twice as is shown by the dates in the above plan of the field.

Every fourth row in the plots I, III and IV, and every third row in plots II and V was left unsprayed as a check. In order more thoroughly to check the results, plot V was divided as shown by the dotted line. Practically the same fungicides were used on the north and the south halves of plot V, but their order was reversed; that is, the same fungicide was applied to the south half of row 43 as to the north half of 77, and the same to the south half of 44 as to the north half of 76, etc.

In plot VI all the rows were sprayed alike with Bordeaux mixture in order to preserve them in as healthy a condition as possible. They were dug at intervals of ten days from August 1st to October 1st, in order to trace the normal development of the tubers. The results are given on page 54.

(2) *Fungicides Tested.* The principal questions in mind in connection with the fungicides were:

1. The relative values of different strengths of Bordeaux mixture for use in spraying potatoes.

2. The value of the soluble (ammonia) compounds as compared with the Bordeaux mixtures.

3. Does the addition of soap increase the values of any or all of these fungicides? *

4. Does the addition of molasses to Bordeaux mixture increase its value?

5. The value of the mixture of copper sulphate and soapstone known in the market as sulphosteatite.

6. The practicability of using a simple solution of copper sulphate.†

Our final conclusions regarding these six points are summarized on page 52.

In seeking answers to these questions we tested some twenty fungicides on the five plots already described.

Following is a list of the fungicides with their composition.

1. Strong Bordeaux mixture: 6 lbs. copper sulphate, 4 lbs. lime, 22 gals. water.

2. Strong Bordeaux mixture, plus soap (Babbitts) at rate of 1 lb. soap to 8 gals. of mixture.

3. Weak Bordeaux mixture: 1 lb. copper sulphate, 1 lb. lime, 10 gals. water.

4. Weak Bordeaux mixture, plus 1 lb. soap to 8 gals. mixture.

5. Weak Bordeaux mixture, plus 1 lb. soap to 16 gals. mixture.

6. Weak Bordeaux mixture, plus molasses, 1 lb. in 10 gals. mixture.

6. Very weak Bordeaux mixture: 1 lb. copper sulphate, 1 lb. lime, 20 gals. water.

7. Very weak Bordeaux mixture, plus 1 lb. soap to 8 gals. mixture.

8. Very weak Bordeaux mixture, plus 1 lb. soap to 16 gals. mixture.

9. Very weak Bordeaux mixture, plus 1 lb. soap to 32 gals. mixture.

10. Ammoniacal copper carbonate: 5 oz. copper carbonate, 3 pints strong ammonia, 45 gals. water.

11. Ammoniacal copper carbonate, plus 1 lb soap to 16 gals. of the solution.

* Soap was added to Bordeaux mixture and other fungicides in order to make them spread over the potato leaves in a more uniform layer. Prof. Beach, of the Geneva, N. Y. Station, used it thus in spraying beans in 1892 and reported excellent results. In Bulletin No. 40, we credited him with being the first to try this soap mixture. We have since learned that Prof. B. T. Galloway, of the U. S. Department of Agriculture, first added soap to Bordeaux mixture and other fungicides in 1891 in certain spraying experiments on wheat (see summary of this work in the Report of Secy. of Agric., 1892, p. 229, and fuller account in Jour. Mycol. Vol. VII, No. 3, p. 202.)

† The simple copper sulphate solution was tested in response to inquiries from Dr. T. H. Hoskins, of Newport.

12. Copper and ammonium carbonates: 1 lb. copper carbonate, 2 lbs. ammonium carbonate, 50 gals. water.

13. Copper and ammonium carbonates, plus 1 lb. soap to 16 gals. of solution.

14. Modified eau celeste: 4 lbs. copper sulphate, 5 lbs. sal soda, 3 pints strong ammonia, 45 gals. water.

15. Modified eau celeste, plus 1 lb soap to 16 gals. of the solution.

16. Modified eau. celeste, plus 1 lb. soap to 32 gals. of the solution.

17. Sulphosteatite, heavy application.

18. Sulphosteatite, lighter application.

19. Copper sulphate, 1 oz. in 100 gals. water.

20. Copper sulphate, 8 oz. in 100 gals. water.

21. Copper sulphate solution No. 20, plus 1 lb. soap to 16 gals.

22. Copper sulphate, 2½ lbs. in 100 gals. water, plus 1 lb. soap to 8 gals.

(3) *Results from Plot I.* Polaris potatoes planted April 29, rows 1 to 10 of Table IV, page 67. The following fungicides were tested on this plot:

(1) Strong Bordeaux mixture; (2) Weak Bordeaux mixture; (3) Same as 2 plus soap; (4) Ammoniacal copper carbonate; (5) Same as 4 plus soap; (6) Modified eau celeste.

The south half of each row was sprayed three times: June 16, July 14, August 1. The north half of each row was sprayed only twice: July 14 and August 1.

The main questions in mind in this experiment were:

1st. Will the spraying of early potatoes for the prevention of the early blight prove profitable ?

2d. If so, what is the best fungicide to use ?

3d. How often should it be applied ?

The following conclusions were reached from the appearance of the plants as seen in the field and the yields as shown in the table on page —:

1. Spraying the early potatoes three times with the Bordeaux mixtures prolonged the life of the plants and apparently increased the yield of marketable potatoes from 170 bushels per acre (average of rows 1 and 10 south*) to 254 bushels (average rows 2, 3 and 4 south), a gain of 84 bushels per acre, or 50%.

2. The Bordeaux mixtures were better than the ammonia solutions. The strong Bordeaux mixture was slightly, if any better, than the weak mixture. The addition of soap to the weak mixture appeared to increase its value considerably (see further discussion as to gain from the addition of soap on page 51.)

3. Three sprayings with Bordeaux mixture gave considerably better results than did two. The average yields of the north halves (sprayed twice) was 224 bushels per acre, while the south halves of the same rows (sprayed three times) averaged 254 bushels. The apparent gain from the extra application was 30 bushels.

The above results show that the spraying of these earliest potatoes was a profitable operation. Estimating the total expense of spraying to be $8.00 per acre, with potatoes at 40 cents per bushel, it would require a gain of only 20

* Check rows 5 and 6 are omitted, as a dead furrow lay between them which probably lessened the yield.

bushels per acre to pay the cost. Our average gain where Bordeaux mixture was used on these potatoes was 75 bushels per acre, and where the soap was added to the mixture the apparent gain was 125 bushels per acre. Owing to our absence during midsummer we were unable to follow the attacks of the fungus and insect enemies. Hence we cannot state the exact cause of this gain. The loss from rot shown in the table (page 67) indicates the presence of the late blight fungus (*Phytophthora infestans*) on even these early plots before they were entirely dead, and the gain from checking this blight and rot doubtless accounts for some part of the gain from spraying.

The foliage of the sprayed rows looked more vigorous than did that of the check rows long before *Phytophthora* appeared. This difference was clearly marked August 1st. On August 12th the following condition was noted: "The unsprayed rows are nearly all dead and where any leaves do remain alive they are badly eaten by the flea-beetle. The sprayed rows are still quite green and show comparatively little damage from the flea-beetles."

Specimens of the leaves collected at this time are infected with the early blight fungus (*Macrosporium solani*), but no trace of the late blight was found. We conclude, therefore, that much of the gain from spraying these early potatoes was in checking the combined ravages of the flea-beetle (*Crepidodera cucumeris*), and the fungus *Macrosporium solani*.

(4) *Results from Plot II.*—Burbank potatoes, planted May 9. Practically the same fungicides were tested as upon Plot I. South half sprayed three times—July 14, August 1, August 15, north half sprayed twice—August 1 and August 15. Rows 11 to 20. See further details of plan and results in Table V, page 67.

It was expected that this plot and all planted later would suffer quite seriously from the late or *Phytophthora* blight, and the results show that such was the case. The gains from spraying were unquestionably due to the combined benefits from ckecking flea-beetle, early blight and late blight and rot.

The general conclusions drawn from Plot II may be summarized as follows:

1. Spraying these potatoes three times with the Bordeaux mixtures gave an average crop of 331 bushels per acre, while the adjoining unsprayed rows averaged but 209 bushels. The gain apparently due to spraying three times was therefore 122 bushels per acre, or 58%.

2. The solution known as modified eau celeste gave as good results as did the Bordeaux mixtures on this plot. The results of our use of this compound in past years as well as this year, lead us to recommend it as the best of the *soluble* fungicides for use in Vermont on potatoes. It is not however equal to Bordeaux mixture on the average and it is more expensive. On the other hand it is much more co venient than Bordeaux mixture to use. The addition of soap proved beneficial here as in Plot I, the apparent gain from its addition to Bordeaux mixture being 24 bushels per acre.

3 Three sprayings gave better results than two. Owing to the fact that conditions were more favorable at the north end of this plot (where it was sprayed only twice) the average yields of the rows sprayed with the Bordeaux mixtures at the north and the south ends are almost the same. When the

yields of the adjoining check rows in each case are taken into account, however, it is seen that the gain from three applications is 122 bushels per acre, or 58% while the gain from two applications is only 80 bushel per acre or 31%.

(5) *Results from Plot III, Polaris potatoes, planted May* 20. The south half was sprayed three times, July 15, August 1 and August 15, the north half twice, August 1 and August 15. For full data as to arrangement and yields see rows 23 to 32, of the Table VI on page 68.

The same fungicides were used as in Plots I and II and modified eau celeste, plus soap, was added to the list.

The results are substantially a verification of those from Plot II with the gains still greater. The rows sprayed three times with the Bordeaux mixtures gave average yields of 352½ bushels per acre of marketable potatoes. The corresponding check rows averaged 159 bushels. The apparent gain was therefore 193½ bushels per acre or 121%. This gain was largely from checking the late (*Phytophthora*) blight as is shown by the average loss from rot, 93 bushels per acre, in the check rows. About one-half of the total gain on this plot was therefore from the prolonged life of the tops and one-half from the checking of the rot.

The modified eau celeste gave as good returns as did Bordeaux mixture and the addition of soap to the latter was advantageous. In these respects the results of the previous plots are confirmed. The apparent gain from the use of soap, however, was but 13 bushels per acre.

Again, also, the advantages of three applications as compared with two are marked as is shown by the following yields:

Bordeaux mixture, 3 applications 352.5 bushels, checks 159 bushels; gain 193.5 bushels or 121%.

Bordeaux mixture, 2 applications 278.5 bushels, checks 172 bushels: gain 106.5. bushels or 62%.

(6) *Results from Plot IV.*—Early Rose potatoes, planted May 20. The entire plot sprayed twice, August 1, and August 16. Rows 33 to 42, see Table VII, page 68, for detailed results.

The same fungicides were tested here as on Plot III. Both the gross yields and the gains from spraying are smaller on this plot than on any other in the series.

The general trend of the results however, is in the same direction as in the preceding plots.

The average yield from the rows sprayed with strong Bordeaux mixture is 246.5 bushels per acre. The average from the corresponding checks is 135 bushels per acre, showing a gain of 111.5 bushels or 81%

The modified eau celeste again compares well with the Bordeaux mixtures.

The addition of soap shows beneficial results though not great enough to signify much; the gain where soap is added to weak Bordeaux mixture being only about 8 bushels per acre.

(7) *Results from Plot V.* White Star potatoes planted May 20, sprayed three times, August 1, 16, 29. As already explained this field was divided into two portions upon which the various fungicides were tested in duplicate series In the following conclusions the average of these duplicates is taken.

The more important results from Table VIII on pages 69 and 70 are embodied in the following:

TABLE, SHOWING MAIN RESULTS FROM PLOT V.

FUNGICIDE.*	Yield, large, sound tubers bu. per A.	Yield, large, rotten tubers, bu. per A.	Gain bushels per acre.	Gain per cent.
1. Sulphosteatite, heavy application	212	77	79	59%
2. Sulphosteatite, light application	162	57	29	22%
3. Checks on 1 and 2	133	117	..	...
4. Copper Sulphate, 1 oz. in 100 gals	200	55	4	2%
5. Copper Sulphate, 8 oz. in 100 gals	224	67	28	14%
6. " " " plus soap	211	95	15	8%
7. Copper Sulphate, 2½ lbs. 100 gals., plus soap	225	108	29	14%
8. Checks on 4 to 7	196	95	..	...
9. Ammoniacal Copper Carbonate	237	137	91	62%
10. " " " plus soap 1-16	239	83	93	64%
11. Checks on 9 and 10	146	108	..	...
12. Copper & Ammonium Carbonate	290	111	195	205%
13. " " " plus soap 1-32	244	118	149	157%
14. " " " plus soap 1-16	250	116	155	163%
15. Checks on 12 to 14	95	143	...	....
16. Modified Eau Celeste	305	87	228	296%
17. " " plus soap 1-32	240	136	163	226%
18. " " plus soap 1-16	274	73	197	270%
19. Checks on 16 to 18	77	152	...	....
20. Strong Bordeaux mixture	417	22	289	226%
21. " " " plus soap 1-8	388	25	260	203%
22. Checks on 16 and 17	128	159	...	....
23. Weak Bordeaux mixture	396	45	248	164%
24. " " " plus soap 1-8	352	29	204	138%
25. Weak Bordeaux mixture, plus soap 1-16	331	91	183	124%
26. Checks on 19 to 21	148	134	...	....
27. Very weak Bordeaux mixture	322	78	188	140%
28. " " " plus soap 1-8	260	79	126	94%
29. " " " plus soap 1-16	281	116	147	109%
30. " " " plus soap 1-32	297	116	163	121%
31. Checks on 23 to 26	134	137	...	....

* The rows from which these results were taken were as follows: *1*, 44 south; *2*, 45 south; *3*, 43 s. & 46 s; *4*, 44 n; *5*, 45 n; *6*, 47 n; 7, 48 n; *8*, 43 n., 46 n. & 49 n; *9*, 47 s; *10* 4 s; *11*, 46 s. & 49 s; *12*, 54 n. & 71 s; *13*, 56 n. & 69 s; *14*, 53 n. & 72 s; *15*, 52 & 55 n., 70 & 73 s; *16*, 57 n; *17*, 59 n; *18*, 60 n; *19*, 58 n. & 61 n; *20*, 56 s. & 69 n; *21*, 51 s. & 68 n; *22*, 55 & 58 s & 67, 70 & 77 n; *23*, 51 n. & 60 s; *24*. 50 n. & 59 s; *25*, 62 s; *26*. 49 & 52 n. & 58 & 61 s; *27*, 51 s. & 74 n; *28*, 50 s. & 75 n; *29*, 53 s. & 72 n; *30*, 54 s. & 71 n; *31*, 49, 52 & 55 s., & 70 & 73 n.

The gain from spraying late potatoes has always been greater with us than from spraying earlier ones. The actual yields from the later potatoes where properly sprayed have also been greater. The results as shown in the above table form a striking illustration of these two facts.

As stated before (p. 42) our loss from rot was unusually heavy in 1893. The loss from rot in the check plots was probably somewhat larger than it would have been had they been dug earlier. It was not thought best, however, to begin digging until the vines in the sprayed plots were entirely dead.

The frosts held off unusually late and many of the sprayed vines of Plot V, remained green until the second week of October, when the last were finally killed by frost. The digging was begun at this time.

The above figures show more strongly than any words the practical value of spraying potatoes in Vermont. It is never safe however, to base conclusions as to the relative merits of fungicides upon figures drawn from so few rows, especially if the fungicides are of nearly equal value. For example: the copper and ammonium carbonate solution which is unquestionably inferior to weak Bordeaux mixture as a fungicide shows returns in the above table in some respects superior to it. We have found the appearance of the plants in the field a more reliable guide in determining the relative values of fungicides than is the yield. The yield is of course largely dependent upon conditions of soil while these soil conditions have less effect upon the blighting of the vines.

Taking all these facts into consideration, we consider the strong Bordeaux mixture unquestionably the best fungicide tested. The weak mixture is nearly as good however. Modified eau celeste is the only other fungicide we can recommend as worthy of use on potatoes in Vermont, and that is not equal to the Bordeaux mixture.

Sulphosteatite, copper sulphate solution and ammoniacal copper carbonate, were all of but slight value as was shown both by the appearance of the vines and by the yields.

Strangely the soap appeared to lessen the value of the fungicides to which it was added upon this plot. The difference is not great, and had it occurred in only one or two rows we should have considered it of no significance. But the cumulative evidence from the various rows where it was used in this plot, makes us confident in our conclusion that it was at least of no benefit, and apparently was an actual injury to the fungicides as used on these late potatoes.

(8) *Potato Plots Sprayed on the State Fair Grounds.* The appearance of our sprayed and unsprayed plots in 1892 formed a very striking contrast even in August. It was decided to plant a piece of potatoes in 1893 on the fair grounds, portions of which might be sprayed and portions left unsprayed, thus forming a valuable object lesson for farmers attending the State Fair in September. Permission was granted us by Mr. Brownell, lessee of the grounds, to use one-fourth of an acre of ground inside the race course. This was planted May 23, to White Star potatoes. Plots were staked off and sprayed July 31 and August 15, as follows:

PLAN OF PLOTS AT FAIR GROUNDS.

Plot 1.	6 rows:	Strong Bordeaux mixture.
Plot 2.	4 rows:	Check.
Plot 3.	4 rows:	Weak Bordeaux mixture.
Plot 4.	4 rows:	Strong Bordeaux mixture.
Plot 5.	4 rows:	Weak Bordeaux mixture, plus soap.
Plot 6.	4 rows:	Check.
Plot 7.	4 rows:	Weak Bordeaux mixture.
Plot 8.	4 rows:	Strong Bordeaux mixture.
Plot 9.	4 rows:	Weak Bordeaux mixture, plus soap.
Plot 10.	4 rows:	Check.
Plot 11.	4 rows:	Strong Bordeaux mixture:

As the blight did comparatively little damage previous to the date of the fair, September first, the contrast between the sprayed and unsprayed plot was not so great as had been expected. It was, however, clearly evident, and much interest in the test was expressed by farmers. Through a misunderstanding Plots 1–5 were dug by Mr. Brownell's men when we were absent and no record of the yields was made. The yields on the duplicate series, 6–11, was as follows:

Check. (Plots 6 and 10.) Marketable, 189 b. per A; rotten, 74 b. per A.
Strong Bordeaux Mixture, (11). Marketable 380 b. per A; rotten 2½ b. per A.
Weak Bordeaux Mixture, (9). Marketable 365 b. per A; rotten, none.
" " " plus soap, (7). Mark'ble 340 b. per A; rotten ½ b. per A.

It will be seen that these results further confirm the conclusions from Plot V. The strong mixture gave a little better result than the weak, and the addition of soap seemed to do harm rather than good. The gain from spraying averaged about 180 bushels per acre; in other words the yield was doubled as a result of only two applications of Bordeaux mixture.

(9) *Effect of Fungicides upon Flea Beetles.* The relation of the flea beetle to the early blight was discussed in our last report, (Report for 1892, p. 67.)

While examining the sprayed and check plots about August 1st, we were impressed with the relative freedom of some of the sprayed rows from the punctures of these little pests.

In order to determine the matter more exactly, Mr. Stevens, on Aug. 12, picked 50 leaves at random from each of a number of rows which had received different treatments. Since many of the early potato plants were dead at this date, these leaves were taken from Plot V. These plants had been sprayed only once, Aug. 1st. The difference was therefore such as resulted from a single application of the fungicides made only twelve days previously, and would doubtless have been more marked on the early planted potatoes could these have been examined.

TABLE GIVING THE NUMBER OF FLEA BEETLE PUNCTURES FOUND IN FIFTY LEAVES FROM EACH ROW.‡

Row		No. of Punctures.
Row 1.	Sprayed with very weak Bordeaux mixture	1794
" 2.	" " " " " " and Soap	1071
" 3.	Not sprayed (check)	2511
" 4.	Sprayed with strong Bordeaux mixture	1194
" 5.	" " " " " and Soap	1090
" 6.	" " weak " "	1295
" 7.	" " " " " and Soap	901
" 8.	Not sprayed (check)	2287
" 9.	Sprayed with Ammoniacal Copper Carbonate	1587
" 10.	" " " " " and Soap	1491
" 11.	" " Modified Eau Celeste	1376
" 12.	" " " " " and Soap	1052

The relative damages from the flea-beetles where these mixtures were used may be graphically expressed, as follows:

Check, 2400 holes.
Very weak B. M., 1794 holes.
Am. Cop. Carbonate, 1587 holes.
Modified Eau Celeste, 1376 holes.
Weak Bord. mixt., 1295 holes.
Strong Bord. Mixt., 1194 holes.
Bord. mixt. and Soap, 945 holes.

These results clearly show that all these fungicides materially checked the ravages of the flea-beetles, and that the addition of soap considerably increased their values in this respect.

The importance of this action of the fungicides should not be underestimated. These flea beetles are so small that they are not generally known to potato growers, who attribute much of the injury caused by them to the larger and better known insects or else to blight.

Two species of flea-beetles were found upon our potato plants last August, the cucumber flea-beetle (*Crepidodera cucumeris*) and the red-headed flea-beetle (*Systena frontalis*.) The former was considerably more abundant than the latter, and to it we attribute most of the damage. This flea-beetle is shown, magnified, in the accompanying figure. Its actual length is about one-sixteenth of an inch, as shown by the line at the left of the figure.

‡ Strong Bordeaux mixture, row 4, consisted of 6 lbs. blue vitriol, 4 lbs. lime 22 gals. water.

Weak Bordeaux mixture, row 6, consisted of 5 lbs. blue vitriol, 5 lbs. lime, 50 gals. water.

Very weak Bordeaux mixture, row 1, consisted of 2½ lbs. blue vitriol, 2½ lbs. lime, 50 gals. water.

Hard soap (Babbitt's) was added to these Bordeaux mixtures (rows 2, 5, 7), at the rate of 1 pound to 8 gallons of the mixture. In the ammonia solutions (Rows 10 and 12), the soap was added at the rate of 1 pound to 16 gallons of the solution.

Like all the rest of the flea-beetles, it has its hind thighs greatly enlarged, and it is thus enabled to jump with great agility when it is disturbed. It is not peculiar to the potato but infests a great variety of plants, including the cucumber, hence its name. It operates by eating minute holes into the substance of the leaf which it attacks, but often not so as to penetrate entirely through it. As shown in the table, fifty or more of these holes were found in each potato leaf examined from our plots of late potatoes August 12th, and we received many leaves from correspondents which were completely riddled with these holes. Harris (*Insects Injurious to Vegetation*, p. 128), reports these beetles as causing serious injury to potatoes in Lowell, Mass., in 1851, and their injuries were even then popularly associated with the potato blight. The above figure, and much of this description, are taken from *Potato Pests*, by Dr. C. V. Riley, Entomologist of the United States Department of Agriculture.

(10) *General Conclusions from the Spraying Experiments of* 1893.—The most important general conclusions from the entire series of experiments in spraying potatoes in 1893, may be briefly summarized, as follows:

FIRST. Our *early* potatoes suffered seriously from early blight and somewhat from the late blight and rot. They also suffered from the attacks of the flea beetles Spraying three times with Bordeaux mixture increased the yields of Polaris potatoes planted April 26, from 170 bushels per acre to 254 bushels per acre. The fungicides were valuable in checking all of the troubles noted above. It is a question just how much of the gain is due to the checking of each of these troubles. The practical outcome is the same, however, viz.: a gain of 84 bushels per acre or 50% from spraying.

SECOND. Our *medium* potatoes (part of which were late potatoes planted early, and part were early potatoes planted late,) suffered also from all three troubles mentioned above, but the proportional loss from the early blight was less, and from the late blight and rot was much greater. The actual gain from spraying was greater than on the early potatoes. Three applications of Bordeaux mixture gave the following gains: Burbank potatoes, planted May 9, sprayed, 331 bushels per acre; not sprayed, 209 bushels; gain 122 bushels per acre, or 58%. Polaris potatoes planted May 20, sprayed three times, yielded 352½ bushels per acre, unsprayed rows yielded 159 bushels, gain 193½ bushels per acre, or 121%.

THIRD. Our *late* potatoes, White Stars, planted May 20, suffered from the late blight and especially from the rot which followed. The yield was increased by three applications of weak Bordeaux mixture from 148 bushels per acre, where not sprayed to 396 bushels where sprayed, a gain of 248 bushels per acre or 164%. The gain where strong mixture was used was even greater.

FOURTH. In all our experiments it has been evident that the strong Bordeaux mixture gives better results than does the weaker mixtures. For use in most cases, however, we recommend a liberal application of the weaker mixture. In cases where the disease is especially threatening it will often pay, we believe, to use a stronger mixture. (See formulas, p. 44.)

FIFTH. The addition of soap to the fungicides when used on early potatoes plainly increased their efficiency. This addition did not appreciably im-

prove their value on later potatoes, but on the contrary it seemed to decrease their beneficial effects. We can see no reason for such decrease. The value of soap where it did appear useful was probably due in part to the fact that it increases the "wetting power" of the fungicide and thus causes it to spread over the leaves in a more uniform layer, and in part due to its repellant effect upon the flea beetles. The soap adds considerably to the cost of the fungicides and makes them more disagreeable to use, and until its value is more fully determined, we do not recommend its general use.

SIXTH. Modified Eau Celeste* is a fungicide nearly equal to the weak Bordeaux mixture in efficiency. It is a solution with no precipitate or sediment to clog the nozzles and can be prepared before hand and kept in concentrated form until needed for use. Against these advantages must be placed its somewhat greater cost. We do not, therefore, recommend it as a substitute for Bordeaux mixture for general use. It is, however, the best *soluble* fungicide we have tested on potatoes and would doubtless be preferable for use in many cases where the nozzles are not suited to Bordeaux mixture.

SEVENTH. The stronger fungicides, particularly the Bordeaux mixture, had a marked effect in keeping the flea beetles from eating the foliage. The addition of soap to the fungicides increased their value in this respect.

EIGHTH. These results lead us to advise the spraying of all potatoes in Vermont with Bordeaux mixture. The date of spraying is very important if the best results are to be secured. From our experience we recommend as follows:

Early potatoes planted April to May 5—spray about July 1, 15, Aug. 1, and again, if needed.

Medium potatoes planted May 5 to May 15—spray about July 15, Aug. 1, Aug. 15, and again, if needed.

Late potatoes planted May 15 or later—spray about Aug. 1, Aug. 14, Aug. 28, and again, if needed.

II. THE TIME AND RATE OF GROWTH OF POTATO TUBERS AND THE EFFECT OF PREMATURE DEATH OF THE POTATO TOPS UPON THE YIELD.

At the close of our experiments each season the question has arisen how much of our gain from spraying has resulted from checking the rot of the tubers, and how much from checking the blight of the leaves and so prolonging the life of the plants.

We have formed estimates each time, and we think, with some degree of exactness. In order to have more complete data this year, however, we staked off a portion of Plot V, after planting, and have labelled this portion of the field Plot VI in the diagram on page 43. This Plot VI contained thirty-five rows. The entire plot was thoroughly sprayed with Bordeaux mixture, August 1st, 16th and 29th, and the plants remained healthy and vigorous up to the last of September. In order to follow the formation and growth of the tubers, five of the rows were dug on August 2d, ten days later, August 12th, five more

**Modified Eau Celeste*:—Dissolve four pounds copper sulphate in ten or twelve gallons of water and stir in five pounds of washing or sal soda; then add three pints of strongest aqua ammonia and dilute to forty-five or fifty gallons (1 barrel.) This is not equal to Bordeaux mixture, but is the best of the *soluble* fungicides for potatoes. If used to excess it may injure the foliage.

were dug, and the digging continued thus at intervals of ten days, five rows each time, until the last were dug October 1st. In order to do away with slight irregularities in soil conditions, we dug August 2d, not five consecutive rows, but rows numbers 1, 8, 15, 22 and 29; August 12th we dug rows 2, 9, 16, 23 and 30, etc. The results of these diggings are shown in the following table:

TABLE III. WHITE STAR POTATOES, PLANTED MAY 20TH. YIELDS AND SIZE OF TUBERS AT DIFFERENT DATES.

Date of digging.		Total Yield per Acre.	Yield of marketable size.†	Average size of Tubers.
Aug.	2	58 bu		1.6 ounces.
"	12	155 "		2. "
"	22	230 "	163 bu	3.7 "
Sept.	1	304 "	234 "	4.4 "
"	12	356 "	303 "	5.2 "
"	22‡	379 "	353 "	5.7 "

Up to the middle of September the tubers were quite immature.

It will be noticed that the total yield is almost exactly doubled during the ten days, August 2 to 12, and again doubled during the second period, August 12 to 22. A glance at the average weight of tubers shows that this was due, in the first period, very largely to the setting of new tubers, the average size increasing but slightly. During the second period the increase was chiefly from growth, and from this time on the increase in average size of the tubers is nearly, though not quite, proportionate to the increase in total yield.

A comparison of total yields, with yields of marketable size, is also instructive, especially the yields from the September diggings. It will be seen that 119 bushels, or over one-third of the marketable potatoes, were formed after September 1st.

The above facts agree with the results of our observations in former years,* and lead us to conclude that the potato crop of Vermont suffers far more each year than is generally realized, from the premature blighting of the vines. Some idea of this loss during the past five years may be formed from the following dates of the appearance of the *late* blight.

In 1889 the late blight struck our field the last week of July and within a few days all the plants were dead.

In 1890 the blight did not appear until about August 20th. All the plants were dead before September 1st.

In 1891 the dates were about the same as in 1890.

In 1892 the blight struck earlier, August 10th, and by the 20th all the unsprayed plants in our fields were destroyed.

In 1893 the disease was later again. It did not spread much until Sep-

† All above 2 oz. in weight were considered of marketable size. Those dug August 2d, and 12th were not assorted.

‡ One of the rows dug October 1st was at the margin of the field by the side of a road, and consequently the yield was small. Except for this one row, however, the yield from this last digging was a few bushels greater per acre than the digging of Sept. 22. The difference was so little that we may safely say that the digging of Sept. 22 represented the full growth of the tubers, although they ripened considerably after that date.

* See Bul. 28, p. 22, and 6th Ann. Rep., pp. 65-6.

tember 1st, and then developed rather slowly. But few unsprayed plants were alive September 10th, however.

The dates when the growth of the tubers was checked during these five years were then about as follows:

1889—August 1st.
1890—August 25th
1891—August 28th.
1892—August 15th.
1893—September 5th.

A comparison of these dates with the corresponding yields in the above table shows at once how great was the loss each of these years from the blighting of the plants. When we add to this loss from premature death, the further loss from rot, we easily comprehend why it has been possible for us to more than double our crop of late potatoes by spraying.

III. RELATION OF TIME OF PLANTING POTATOES TO THE DISEASES.

In our study of potato diseases we have been impressed more and more with the very different conditions surrounding early and late potatoes. Early potatoes form their tubers largely during the dryer weather of July, then weakened by this effort succumb readily to the combined effects of dry weather, insect attacks, and the early blight fungus. They thus are entirely dead before the late blight appears, or so nearly so, that they suffer but little from it. Late potatoes, forming their tubers during August and early September, have most favorable conditions of moisture and experience little trouble from insects, but are almost certain to suffer seriously from the late blight and rot. The loss from this disease has been so great that Vermont farmers have largely abandoned the practice of late planting. At the same tine it is generally recognized that much larger crops can be obtained from late planting, providing the danger from blight and rot can be avoided. The success of the Bordeaux mixture in thus preserving the crop raises the question whether it will not prove more profitable in most cases to plant late and spray with Bordeaux mixture. As a rule the early potatoes bring a higher price if placed on the market in July and August. We are satisfied from our experiments, however, that very much larger yields can be obtained from the later planting. Aside from the loss to early potatoes from the dry weather, they suffer seriously, as before stated, from the attacks of flea-beetles and early blight.

We can, by spraying, do much to check these troubles, as shown by our results on Plot I. But it requires more expense and painstaking to thus care for our early potatoes than it does to protect our later ones. Where one is working merely for the largest crop with the least work in protecting it, we therefore recommend planting about May 10th to 20th. The crop will thus escape the early blight so that the spraying need not begin until about August 1st. Two or three applications of the Bordeaux mixture will then carry the crop to maturity.

IV. A SPRAY CART FOR POTATOES.

The most serious practical difficulty in the use of the Bordeaux mixture on potatoes is to find a cheap and convenient means of applying it. On small fields many use a watering-pot or a pail and brush broom, but either way is slow work and is moreover very wasteful of the mixture. Such means should only be resorted to when there is no better way. Hon. H. W. Vail, of Pomfret, says that he has sprayed his field of one-half acre satisfactorily with a brass hand-pump, such as is sold for washing windows, etc. This pump was set in a tub which two men carried through the field, stopping about once in twenty feet and spraying the plants about them as far as they could force the mixture.

We use a Galloway Knapsack Sprayer in our experimental work in small plots. This form of sprayer works very satisfactorily. It applies the mixture uniformly, thoroughly, and economically, and for small fields is the ideal machine. The objections to the Knapsack sprayer are its cost, the labor of carrying and operating, and the length of time required to cover a large field with one of them. There is, therefore, the need of some other apparatus for spraying the larger potato fields. The best machine for this purpose is a strong force pump mounted on a large barrel. A number of pump manufacturers are making a specialty of such force pumps. The mounting of the pump and the arrangement of the cart are, however, usually left to the purchaser. We fitted up a spray cart for our work last summer which proved so satisfactory that we recommend the general use of something of the kind. As most of such an outfit is necessarily "home-made," we will illustrate and describe it in detail.

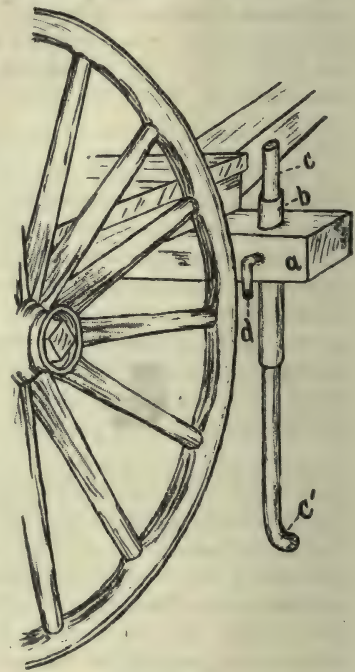


Figure 12.

Figure 12. Device for guard to keep plants from under the wheel. *a*, cross-beam, 2 by 4 inches, hard wood; *b*, ⅞-inch gas pipe; *c*, *c'*, ¾ inch iron rod; *d*, set-screw.

Figs. 12 and 13 show the main features of the cart. The apparatus consists of a force-pump mounted on a large kerosene barrel. This is carried on a two-wheeled cart. The mixture from the pump is forced through four spray nozzles at the rear end of the cart. We plant in rows three feet apart and the cart wheels are set six feet apart so as to straddle two rows while the horse walks between these rows. A perpendicular rod was placed just in front of the wheel as a guard to pick up and separate the vines. It served its purpose so well that we show its arrangement in detail in Fig. 12. The

guard rod, c, is of ¾-inch iron, bent forward at its lower end c' b is a piece of gas-pipe, ⅞-inch bore, just large enough to allow the rod c to pass through without binding. This pipe b serves to stiffen c and also to receive the thread of the set-screw, d. When in the field the point c' is lowered

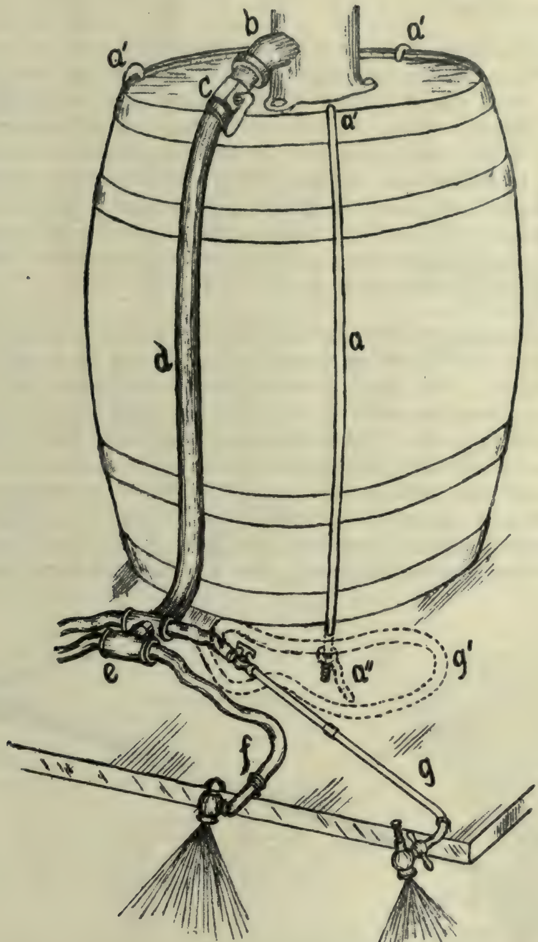


Figure 13.

Figure 13. a, one of three rods for fastening barrel to cart, hooked over the chime of barrel at top a', a', a', and fastened with hand nut under bed of cart, a''; b, pump discharge; c, shut off, d, ¾-inch rubber hose; e, T connections; f, common Vermorel nozzle connected with 3 feet of ¼-inch (linen insertion) hose; g, Boekel "under-sprayer;" g', 3 feet extra hose for extending g to outer row when four rows are to be covered.

as near to the ground as possible, without striking. Upon driving from the field for water, etc., it is but a moment's work to loosen the set-screw at *d* and raise the rod. A cheaper way, though not quite so strong, is to run this guard rod, *e*, along the back side of the cross-beam, *a*. It is held in place at any height by a j-shaped bolt passing through the beam, *a*, and having a hand-nut at its opposite end.

The arrangement of the hose and nozzles is shown in Fig. 13. The pump need have but one discharge orifice, *b*, from which a single piece of ¾-inch hose or gas pipe, *d*, passes. A valve located at *c*, will be found a great convenience, though not a necessity. The four tubes leading from the bottom of *d* to the nozzles (only two of the four nozzles are shown in this figure) may be rubber hose (¼-inch linen insertion hose), as shown in *f*, or better (as shown in *g*), a short length of hose connecting with a brass tube having the nozzle at its end. Such a tube fitted with nozzle and stop-cock, and exactly adapted for this use is made by Wm. Boekel & Co., 518 Vine St., Philadelphia, and is shown more in detail in Fig. 14.

When the plants are nearly or quite full grown it is necessary to have two nozzles directed on each row, as shown in Figs. 11 and 13, in order to spray them thoroughly. The spray from one nozzle over each row should be directed ahead under the cart, and that from the other directed backward, in order to cover all leaves. The advantage of the union joint of the Boekel under-sprayer for adjusting the nozzle is obvious. One nozzle over each row may prove sufficient with younger plants. In order to arrange for that, an arm three feet long can be extended from the cart, back of each wheel, and the outer nozzles (which must in that case have three feet of extra hose as shown in *g'*), can be extended on these arms. The cart thus rigged will serve admir-

Figure 14.

Figure 14. The Boekel "undersprayer:" A, Vermorel nozzle; B, union joint to hold the nozzle in any desired position (for potatoes the spray should be directed down instead of up); C, degorger, for cleaning nozzle; D, shut-off. The lance is three feet in length, jointed in the middle as shown in *g*, Fig. 13.

ably for applying Paris green in water for the potato beetles during the early part of the summer.* Two men with such cart can cover five to ten acres in a day, if water is convenient.

When the lime is added to the blue vitriol in making the Bordeaux mixture, it forms an insoluble compound. In order to keep this from settling it is necessary that the mixture be constantly stirred while being applied. Many spray-pumps have small return tubes which discharge a portion of the mixture back into the barrel. This may suffice with Paris green mixtures, but with Borbeaux mixture we have not found it sufficient. Some kind of dasher or "agitator" is necessary to do this mixing properly. Several pump firms furnish such with their pumps when wished. Figure 15 shows a simple form which can be made easily by anyone, and which we have found satisfactory.

Instead of mounting the pump on the head of the barrel as shown in the previous figures, it may be placed on the side of the barrel. The pump-handle is thus brought lower, the opening in the barrel also being lower, makes it easier to fill and the cart rigged thus is less top-heavy. Figure 16 shows a simple device for an agitator when the pump is so mounted.

In arranging a spray cart it will probably be well to buy the pump without the attachments (hose and nozzle), which are usually quoted with the pump in catalogues. Four nozzles and hose, if wished, can then be ordered in addition. The remainder of the fittings can all be had from the local blacksmith and tinsmith, or plumber. The best nozzle for use with the Bordeaux mixture on potatoes, is what is generally called the "Vermorel." (Fig. 17. See also Fig. 14.) It is not patented, and so is made and offered for sale in some form by all manufacturers of spray-pumps.

Figure 15.

Figure 15. Device for stirring the Bordeaux mixture. The rod, *i m*, 8 inches long, is bolted firmly to the pump handle at *i*, and jointed loosely at *m* to another rod which passes through the head of the barrel at *n*, and has at its lower end a dasher, *o*.

*When Paris green is mixed with water alone, there is more danger of its injuring the foliage than where the poison is applied dry with plaster. This danger is entirely removed if lime is added to the water. Mix with the Paris green an equal weight of fresh lime, stir this mixture up thoroughly in a pail of hot water, and allow it to stand a couple of hours before applying. Use at the rate of ½ pound of Paris green per barrel of water or Bordeaux mixture.

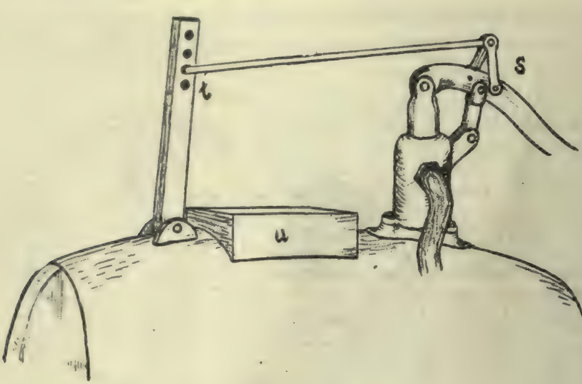


Figure 16.

Figure 16. Showing pump mounted on side of barrel. The agitator, *t*, is connected with the pump-handle at *s*; *u*, opening for filling the barrel. (This opening should have a tight cover.)

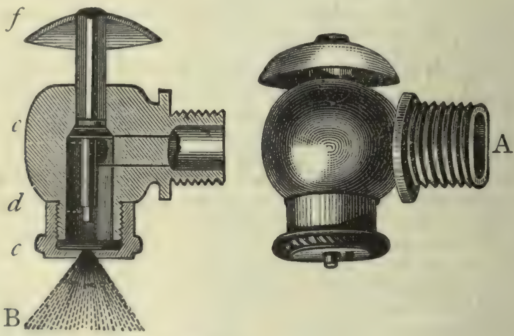


Figure 17.

Figure 17. The Vermorel nozzle. A, entire; B, in section; *c*, removable cap; *d*, end of cleaning rod; *e*, rubber casket to prevent backward escape of liquid; *f*, cap to hold liquid when rod is pushed forward. (From Insect Life, Vol. 1, No. 9.) Instead of the cap, *f*, most nozzles are now made with the coil spring as shown at *c*, Fig. 14. We prefer those having this spring.

V. THE LOSS FROM OAT SMUT IN VERMONT IN 1893.

Two lines of investigation concerning oat smut were pursued during the years 1890-2. These were: first, *The best remedy for oat-smut;* second, *The actual loss from this disease in Vermont.*

The results obtained from the Jensen hot water treatment as a remedy for oat-smut were so satisfactory that we considered further experimental work in 1893 with this or any other remedy to be unnecessary. We simply repeat here the directions published in Bulletin No. 32, for disinfecting seed oats.

THE JENSEN HOT WATER TREATMENT FOR SEED OATS.

"Dipping smutted seed oats for a few minutes in hot water destroys every smut spore and insures a crop free from smut. The method is simple, and there is no expense except the slight labor involved. Soak the seed oats about ten minutes in water heated to 130°—135° F., then spread at once where they can drain and dry as rapidly as possible. Each man can arrange details of treatment according to his conveniences—the following method is simple and good:

Have a large barrel half full of water heated to 135°—140°. Put half a bushel of oats in a fertilizer sack and immerse in the water, stirring them so that they heat through alike; keep your thermometer in the water, and if the temperature remains above 135° take the oats out at the end of five minutes. If it falls lower than 135° let them soak longer (ten or even fifteen minutes). In order to control the temperature, have a good supply of hot and of cold water handy to add, as necessary. In brief:

With	temperature	135° to 140°	soak	five minutes.
With	"	130° to 135°	"	ten "
With	"	128° to 132°	"	fifteen "

Below 130° does not destroy all smut, and soaking longer than five minutes above 140° or 145° injures the seed."

The second question—namely, the amount of loss from oat smut in Vermont—was made the subject of further study in 1893. As this work was a direct continuation of that of 1892, it will be necessary briefly to review the results of the work of previous years and more especially that of 1892.

Examinations of a few fields made in 1891, led us to believe that oat smut was less prevalent in Vermont than it had been reported to be in other states where examinations had been made. In order to investigate the matter better, in 1892 we wrote to one hundred farmers of the state, asking that each send us samples from his oat field. Samples from eighty-two fields were thus secured, and were carefully examined for smutty heads. The results were as follows:

From 47 fields where Vermont seed was sown, 1% of the heads were smutted.

From 20 " " Western " " " 3.13% of the heads were smutted.

From 15 " " seed from other sources, 1.34% of the heads were smutted.

Average of all samples examined showed 1.6% of smut.

From this examination we drew the following conclusions:

First. In general, the loss from oat smut in this state where native seed is used, is not large enough to demand the use of the hot water or other method for disinfecting the seed.

Second. The average loss from oat smut where western* seed is used, is considerably greater than where native seed is used, being in the samples examined over three times as great.

* Large quantities of oats are brought into Vermont, each year, from the Chicago markets. They are known as "western" oats. Probably Iowa furnishes more of these than any other one state.

The result should be especially encouraging to our oat-growers as is shown by the following statements concerning the loss from oat-smut in other states.* The loss from smut in New York State has been estimated (1885) at 10 per cent. of the entire crop. In Kansas (1888–91) the loss was estimated at 6 per cent. to 11 per cent.; In Indiana (1891) at 10 per cent.; in Michigan (1891) 15 per cent.; in Wisconsin (1891) the total loss is placed as greater than that of Michigan.

In view of these estimates, the U. S. Dept. of Agriculture in a recent bulletin, states that "the average loss is from 5 to 12 per cent. in different localities in the United States," while another good authority, Dr. Arthur, in a recent article, states that this country loses annually, from smut, "nearly or quite 10 per cent. of the total oat crop."

The remarkable difference between the results of our examinations in Vermont, and those reported from these other states, made it desirable that we make a similar examination another year. The amount of smut may vary also from year to year. Requests were therefore sent in 1893 to those who had sent samples in 1892. These requests were accompanied by the following directions for taking and sending the samples.

DIRECTIONS FOR TAKING AND SENDING OAT SAMPLES.

Taking the samples.—Take the samples as soon as the oats are fully headed out. The object is to get a fair and impartial sample of the field. For this purpose we wish five samples taken from different parts of the same field. In order to have all samples of same size, take a barrel-hoop into the field with you, drop it down into the grain and pull up by the roots all the grain enclosed by the hoop. Take in this way five samples from different parts of the same field, tying a string around each sample so that they can be separated when examined.†

Sending the samples.—Shake dirt off from the roots, wrap all in a heavy paper or fertilizer sacking, attach the enclosed shipping tag, and send to us by express. Please fill out blank spaces on the back of the shipping tag, stating source of the seed, etc.

Sixty-nine samples were received in reply to these requests. Sixteen samples were collected from as many different fields about Burlington by assistant, C. E. Stevens, and eleven samples were collected at Morrisville by Fred Small, making a total of ninety-seven samples. These were all carefully examined. In order to show the results more clearly, the samples are arranged in the order of smuttiness, and are placed in the following tables according to the source of the seed.

* For further details and authorities, see sixth An. Rep. Vt. Exp. Sta. 1892, p. 81.

† In 1892 we directed that samples be cut close to the ground. We had them pulled this year at the suggestion of Dr. J. C. Arthur, of the Indiana Experiment Station, in order to avoid any danger of losing the shorter smutted heads.

TABLE I—VERMONT SEED.

No.	NAME.	ADDRESS.	Sound Heads	Smutty Heads	Per Cent of Smut.	Was sample sent last year from same strain of seed?
96	E. R. Pember	Wells	314	3	.3	Yes
•	Hiram M. Small	Morrisville	283	8	2.75	
36	J. R. Kenerson	Peacham	373	9	2.36	No
	Sheldon Tewksbury	Morrisville	215	5	2.27	No
	Warner Gilbert	Morrisville	230	4	1.7	
10	G. S. Fassett	Enosburgh	416	7	1.65	No
18	Geo. C. Kelsey	Irasburgh	603	10	1.6	No
95	J. S. Wheeler	Waterbury	251	4	1.6	Yes
	S. W. Palmer	Morrisville	349	4	1.41	
3	Carl Yante	Hinesburgh	275	4	1.4	
64	L. C. Fisher	Cabot	434	6	1.4	No
77	T. H. Wheatley	Brookfield	375	5	1.3	Yes
	Levi K. Small	Morrisville	164	2	1.2	No
2	William Babcock	Williston	253	3	1.17	
13	C. Miller & Son	Pomfret	380	4	1.05	Yes
19	C. C. Forbes	Shoreham	275	3	1.	Yes
112	Chas. Winterbottom	Shelburne	599	6	1.	
	P. Franklin Spaulding	Morrisville	208	2	1.	No
	E. R. Towle	Enosburgh Falls	368	3	.8	
40	Alpha Messer	Rochester	408	3	.75	Yes
54	G. B. Brewster	Irasburgh	472	3	.70	
	Charles McCarty	Morrisville	304	2	.65	
58	C. M. King	Benson	318	2	.6	No
54 III	E. O. Whipple	Irasburgh	686	4	.6	
94	A. A. Rogers	Underhill	686	4	.58	No
84	D. R. Pierce	Waterville	985	5	.5	Yes
102	Daniel Coyous	Shelburne	404	2	.5	
111	L. F. Lyon	Shelburne	433	2	.5	No
67	Alpheus S. Hibbard	East Brookfield	436	2	.46	No
63	W. A. Small	Morrisville	650	3	.46	
66	C. P. Crane	Bridgeport	439	2	.45	
12	Cassius Peck	Brookfield	422	2	.4	Yes
75 II	Joseph Bootah	Brookfield	521	2	.4	
114	Thomas Connor	Burlington	640	2	.32	No
5	A. D. Ufford	Fairfax	268	1	.27	No
81	S. A. Underwood	Westminster	359	1	.25	No
10	Albert Town	Jonesville	421	1	.24	Yes
1	Fred Lavigne	Hinesburgh	438	1	.23	
43	E. H. Cleveland	Franklin	458	1	.2	Yes
104	J. W. Noonan	Shelburne	575	1	.17	
108	Thomas Cozans	Shelburne	601	1	.16	
8	M. V. Willard	Jericho Center	662	1	.15	
10	B. S. Balch	Jericho Center	407	0	.0	Yes
103	J. S. Benedict	Shelburne	361	0	.0	No
	John M. Campbell	Morrisville	220	0	.0	No
32	W. W. Clark	No. Williston	215	0	.0	Yes
105	H. M. Cleveland	Shelburne	471	0	.0	No
15	G. H. Dunsmore	St. Albans	609	0	.0	No
	Edwin Dyke	Morristown Center	405	0	.0	No
75 IV	M. P. Goodrich	Morristown Center	517	0	.0	
71 B	C. W. Goodwin		414	0	.0	No
49	C. P. Gordon	Pearl	269	0	.0	Yes
71	J. F. Hemenway, field of C. C. Scales	Chelsea	176	0	.0	No
113	Homer Irish	Shelburne	456	0	.0	
82	J. A. James	Weybridge, (P. O. Middlebury)	541	0	.0	No
75	T. D. Jameson	Alburgh	345	0	.0	Yes
107	W. E. LaBrese	Burlington	408	0	.0	No
57	H. Lawrence	St. George	316	0	.0	Yes
101	George Munroe	Shelburne	569	0	.0	No
44	L. W. Peet	Cornwall	244	0	.0	Yes
54 I	H. W. Priest	Irasburgh	472	0	.0	
75 I	Geo. H. Sheldon	Irasburgh	276	0	.0	
25	Ezra Stevens	Jonesville	567	0	.0	Yes
39	P. K. Spaulding	Proctorsville	250	0	.0	Yes
86	O. E. Stone	Charlotte	368	0	.0	No
69	G. M. Webster	Cabot	316	0	.0	No
41	C. M. Winslow	Brandon	298	0	.0	No

Total number heads examined 26,806. Average per cent. of smut found, 0.56.

TABLE II—WESTERN SEED.

No.	NAME.	ADDRESS.	Sound Heads	Smutty Heads	Per cent of Smut.	Was sample sent last year from same strain of seed?
2	Charles A. Peck	New Haven	219	16	7.	No
70	Ira E. Morse	Cambridge	463	23	4.7	No
17	A. A. Pierce	St. Johnsbury C't'r	691	33	4.52	No
	Chas. McCarty	Morrisville	209	8	3.7	No
6	E. B. True	Newport	361	7	1.9	Yes
76	H. J. Parker	Andover	191	3	1.9	Yes
106	J. W. Noonan	Shelburne	475	7	1.45	
54	Joseph Cook	Irasburgh	564	7	1.2	
28	LaRoy Southworth	Middletown Sp'ngs	420	5	1.2	Yes
54	Moses Burbank	Irasburgh	374	4	1.	
65	O. L. Miner	Brattleboro	218	2	.9	No
109	E. H. Palmer	Shelburne	489	4	.8	
	John Perry	Morrisville	152	1	.65	No
98	John Whitcher	Walden	748	27	.4	No
62	J. O. Sanford	Stamford	541	1	.2	Yes
27	J. E. Sherburne	North Pomfret	551	1	.18	Yes
27–3	Noah Preston	North Pomfret	568	1	.17	No
27–4	S. S. Hildreth	North Pomfret	309	0	.0	No
	Ernest L. Kelley	West Salisbury	266	0	.0	No
7	D. E. Gibson	West Salisbury	410	0	.0	No

Total number of heads examined, 8388.
Average per cent. of smut found, 1.57.

TABLE III—SEED FROM OTHER OR UNKNOWN SOURCES.

No.	NAME.	ADDRESS.	Sound Heads	Smutty Heads	Per cent of Smut.	Was sample sent last year from same strain of seed?
87	A. A. Storrs	Burlington	346	13	3.6	
2	C. H. Maxham	South Pomfret	209	3	1.4	No
73	A. O. Edson	Chester	213	2	.93	No
74	J. E. Chamberlin	Barton Landing	378	3	.79	Yes
75	Lewis Turner	Alburgh	303	2	.66	Yes
100	J. W. Wright	Pownal	608	3	.05	
110	Lewis Shavanaw	Burlington	443	2	.45	
91	Geo. S. Worcester	Thetford	260	1	.4	No
42	T. E. Putman	East Cambridge	726	2	.3	No
79	E. W. Fitch	Wilmington	298	0	.0	Yes
45	Dwight Sykes	Dorset	436	0	.0	Yes
39 A	P. K. Spaulding	Proctorsville	384	0	.0	No

Total number of heads examined, 4,361.
Average per cent. of smut found, .92 per cent.
From Tables I, II and III, we have,
Total number of heads examined, 36,648
Average per cent. of smut found in all samples, .76.

A comparison of these figures, with those obtained in 1892, proves interesting. For convenience we place the results of the two years, in the following tabular form.

The reduction where the Western strain of seed was used thus amounts to 2.21%, or over two-thirds of the amount of last year. In contrast to this the Vermont strains of seed which were represented in the samples of both years, showed a reduction of but one-third. The evidence from all sources points to

one conclusion, namely, that *certain conditions affecting the oat crop in Vermont are unfavorable to the development of smut as compared with the conditions of many, if not most, other sections of the United States.*

			Vermont Seed.		Western Seed.		Seed from other Sources		
	No. of Fields Sampled.	Total No. of Heads Examined.	Number of Samples.	Amount of Smut.	Number of Samples.	Amount of Smut.	Number of Samples.	Amount of Smut.	Average amount of Smut in all Samples.
1892	81	35177	47	1.%	20	3.13%	15	1.34%	1.60%
1893	98	39826	66	0.56%	20	1.57%	12	.92%	.82%

Considerable surprise was expressed by investigators in other sections of the country at the small amount of smut found by us in 1892. A glance at the above table shows that even less was found in 1893. As already noted, also the extra precaution of pulling all samples was taken in 1893 that no smutty heads be lost. Seventeen of the samples sent were from strains of native grown seed from which samples had been sent in 1892.

An opportunity was thus given for even more direct comparison of the amounts of smut occurring during these two years. The results from these samples in 1892 and 1893, are as follows:

Average amount of smut, 17 fields, Vermont seed, 1892, .88%.
Average amount from same strain of seed, 1893, .60%.

This shows again, that there was less oat-smut in Vermont in 1893 than there was in 1892. The most striking reduction in the amount of smut was found in those samples where Western seed was used in 1892, and the product of this again planted in 1893. The cases were as follows:

	Amount of Smut in 1892.	Amount of Smut; same strain of seed in 1893.
Sample No. 6	4.91%	1.90%
" " 76	2.89%	1.50%
" " 28	3.60%	1.20%
" " 27	2.13%	.18%
" " 75 III	2.96%	.66%
Averages	3.3%	1.09%

Tables showing results of spraying potatoes with various fungicides.

TABLE IV.—PLOT I. POLARIS POTATOES, PLANTED APRIL 20.

No. of Row.	FUNGICIDE USED.	SOUTH HALF OF PLOT Sprayed 3 times, June 16, July 14, August 1. — Yields in Bushels per Acre. — Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	Average Weight of Tubers in Ounces	NORTH HALF OF PLOT Sprayed twice, July 14, August 1. — Yields in Bushels per Acre. — Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	Average Weight of Tubers in Ounces
1	None	172.2	14.9	17	0	3.36	188.1	16.7	21.8	6	3.99
2	Strong Bordeaux Mixture	232	19.9	5	0	4.14	229.9	27	7.1	0	3.15
3	Weak Bordeaux Mixture	236.3	25.6	2.8	0	3.78	203.5	21.3	0	0	3.91
4	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)	294.7	37	10.6	0	3.74	237.7	24.9	4.3	0	3.87
5	None	158	21.3	4.3	0	3.12	152.3	19.2	1.4	0.7	3.19
6	None	95.4	16.3	2.8	0	3.30	162.3	15.6	4.3	0	3.58
7	Ammoniacal Copper Carbonate.	166.5	22.8	11.4	1.4	2.98	196.4	21.3	7.1	0	3.31
8	Am.Cop. Carb.+Soap (1 lb.to 16 gals.)	166.5	21.3	7.1	0	3.21	197.9	18.5	5.7	0	3.36
9	Modified Eau Celeste	209.3	22	5.7	0	3.49	180.8	22.7	12.8	0	3.86
10	None	168	25.6	14.2	0	3.24	163.7	22.8	17.1	1.4	3.14

TABLE V.—PLOT II. BURBANK POTATOES, PLANTED MAY 9.

No. of Row.	FUNGICIDE USED.	SOUTH HALF OF PLOT Sprayed 3 times, July 14, Aug. 1, Aug. 15. — Yields in Bushels per Acre. — Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	Average Weight ef Tubers in Ounces	NORTH HALF OF PLOT Sprayed twice, Aug. 1, Aug. 15. — Yields in Bushels per Acre. — Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	Average Weight of Tubers in Ounces
11	None	202.1	13.5	57.7	3.5	4.67	222.8	14.9	32.7	1.4	4.53
12	Strong Bordeaux Mixture	353	28.4	13.5	0	5.04	343.1	14.2	2.1	0	5.87
13	Weak Bordeaux Mixture	307.5	25.6	14.2	0	4.79	287.5	24.2	9.9	0	5.02
14	None	216.4	22.7	28.5	5	3.96	245.5	21.3	66.2	4.3	4.42
15	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)	331.7	37	16.3	0	4.67	367.3	25.6	11.4	0	5.11
16	Modified Eau Celeste	339.5	35.6	13.5	0	6.16	325.8	24.9	9.9	0	5.69
17	None	244.8	19.2	56.9	1.4	5.29	284	18.5	34.2	5.7	5.13
18	Ammoniacal Copper Carbonate	273.3	22.8	42.7	1.4	4.84	267.6	14.2	31.3	0	5.35
19	Am. Cop. Carb.+Soap (1 lb. to 16 gals.)	298.9	14.2	25.6	2.1	5.67	274	16.3	27	1.4	5.58
20	None	219.2	22.8	64.1	2.8	4.31	310.3	17.1	14.2	1.4	4.77

Tables showing results of spraying potatoes with various fungicides.

TABLE VI—PLOT III. POLARIS POTATOES, PLANTED MAY 20.

No. of Row.	FUNGICIDE USED.	SOUTH END OF PLOT Sprayed 3 times, July 15, Aug 1, Aug. 15.					NORTH END OF PLOT Sprayed twice, Aug. 1, Aug. 15.				
		Yields in Bushels per Acre.				Average Weight of Tubers in Ounces	Yields in Bushels per Acre.				Average Weight of Tubers in Ounces
		Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers		Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	
23	None	148	5.7	113.9	1.4	6.27	205	24.2	39.8	0	4.55
24	Strong Bordeaux Mixture	313.1	7.1	8.5	0	6.11	247.7	22.8	2.1	0	6.05
25	Weak Bordeaux Mixture	365.8	8.5	4.2	0	6.82	300.3	18.5	2.1	0	5.04
26	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)	378.5	7.1	0	0	7.95	287.5	22.8	11.4	0	4.88
27	None	169.4	9.9	71.2	1.4	5.32	139.5	18.5	54.1	0	3.89
28	Modified Eau Celeste	374.4	4.3	5	0	7.23	253.4	18.5	7.1	0	4.46
29	Mod. Eau Cel.+Soap (1 lb. to 16 gals.)	358.7	8.5	5	0	7.38	395.7	21.4	11.4	0	5.52
30	Ammoniacal Copper Carbonate	238.2	13.5	38.4	0.7	5.09	200.7	17.1	22.8	1.4	4.23
31	Am. Cop. Carb.+Soap (1 lb. to 16 gals.)	227.8	9.2	34.2	0	6.07	220.6	22.8	32.8	0.7	4.77
32	None	210.7	12.1	31.3	0.7	5.03	185	10	19.9	0	4.64

TABLE VII.—PLOT IV. EARLY ROSE, PLANTED MAY 20.

No. of Row.	FUNGICIDE USED.	SOUTH HALF Sprayed twice, Aug. 1, Aug. 16.					NORTH HALF Sprayed twice, Aug. 1, Aug. 16.				
		Yields in Bushels per Acre.				Average Weight of Tubers in Ounces	Yields in Bushels per Acre.				Average Weight of Tubers in Ounces
		Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers		Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	
33	None	112.5	12.8	64	0	3.29	142.3	65.5	2.8	0	2.92
34	Strong Bordeaux Mixture	172.2	22	5	0	3.24	143.7	9.2	0	0	3.02
35	Weak Bordeaux Mixture	170.8	21.3	2.8	0	2.77	156.6	21.3	2.8	0	2.77
36	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)	194.9	28.5	0.7	0	4.16	148	37	2.1	0.7	2.61
37	None	150.9	14.2	11.4	0	2.93	135.2	14.2	14.3	0	2.90
38	Modified Eau Celeste	220.6	22.8	5.7	0	3.38	112.5	18.5	4.3	0	1.90
39	Mod. Eau Cel.+Soap (1 lb. to 16 gals.)	222.1	24.9	9.9	0	3.89	163.7	22	2.1	0	3.07
40	Ammoniacal Copper Carbonate	175	23.4	6.4	0	3.28	173.6	19.2	4.3	0	3.40
41	Am. Cop. Carb.+Soap (1 lb. to 16 gals.)	224.8	22.8	11.4	0.7	3.47	189.2	24.9	5	0	3.33
42	None	194.9	16.3	21.3	0.7	3.72	156.6	23.4	0.7	0	2.92

Tables showing results of spraying potatoes with various fungicides.

TABLE VIII.—PLOT V. WHITE STAR POTATOES, PLANTED MAY 20.

No. of Row.	FUNGICIDES USED.	SOUTH END. Sprayed Aug. 1, 16 and 29. Yield in Bushels per Acre. Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	Average Weight of Tubers in Ounces
43	None..................................	141	7.5	116.8	5.8	4.45
44	Sulphosteatite, heavy application...........	211.9	10	76.7	1.7	4.63
45	Sulphosteatite, light application............	161.8	10.9	56.7	4.2	4.15
46	None	725.1	10.9	116.8	6.7	4.64
47	Ammoniacal Copper Carbonate.............	236.9	25	136.8	5.8	5.51
48	Am. Cop. Carb.+Soap (1 lb. to 16 gals.).....	238.6	11.7	83.4	3.3	5.57
49	None	166.8	13.4	100.1	5	4.76
50	Very Wk. Bord. Mixt +Soap (1 lb. to 8 gals.)	300.4	8.3	55	0.8	5.95
51	Very Weak Bordeaux Mixture..............	379.6	19.2	50	9.2	6.65
52	None	159.3	10.9	131	3.3	4.66
53	Very Wk. Bord. Mixt.+Soap (1 lb. to 16 gals.)	335.4	13.3	70.1	3.3	6.44
54	Very Wk. Bord. Mixt.+Soap (1 lb. to 32 gals.)	343.7	16.7	93.4	2.5	5.78
55	None..................................	112.7	16.7	156.8	6.7	4.22
56	Strong Bordeaux Mixture..................	407	26.7	20.8	4.2	5.61
57	Str. Bord. Mixt.+Soap (1 lb. to 8 gals.)....	390.4	28.4	5.8	2.5	6.18
58	None..................................	166.8	20	123.4	10.9	4.41
59	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)....	349 5	20.8	28.4	1.7	6.07
60	Weak Bordeaux Mixture..................	400.4	27.5	39.2	0.8	6 14
61	None..................................	75	10.9	150.2	6.7	4.86
62	Wk. Bord. Mixt.+Soap (1 lb. to 16 gals.)...	330.6	16.7	91	5.8	5.54
63	Wk. Bord. Mixt.+Molasses................	342	15	56.7	7.5	5.75
64	None..................................	70.1	18.4	176.8	11.7	4.11
65	Mod. Eau Celeste+Soap (1 lb. to 16 gals.)...	257	14.2	128.5	11.7	5.46
66	Modified Eau Celeste....................	113.4	....	......	....	....
67	None..................................	98.5	26.7	166.8	6.7	4.08
68	Mod. Eau Celeste+Soap (1 lb. to 32 gals.) ..	......	....	.....	....	5.11
69	Cop. and Am. Carb.+Soap (1 lb. to 32 gals.)	216.9	16.7	150 2	13.3	4.44
70	None..................................	83.4	16.7	155.1	15.9	3.73
71	Copper and Ammonium Carbonates.........	272	15	108.4	21 7	4.71
72	Cop. and Am. Carb.+Soap (1 lb. to 16 gals.)	251.8	15	106.8	5.8	5.62
73	None..................................	63.4	6.7	110.1	10	5.33
74	Weak Bordeaux Mixture..................	320.3	16.7	73.4	5	5.01
75	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)....	323.7	20	80.1	13.3	5.50
76	None..................................	163.5	40.1	56.7	6.7	2.94
77	None..................................	103.4	6.7	120.1	10	4.34

Tables showing results of spraying potatoes with various fungicides.

TABLE VIII CONTINUED—PLOT V. WHITE STAR POTATOES, PLANTED MAY 20.

No. of Row.	Fungicides used.	North end. Sprayed Aug. 1, 16 and 29. Yield in Bushels per Acre. Large Sound Tubers	Small Sound Tubers	Large Rotten Tubers	Small Rotten Tubers	Average Weight of Tubers in Ounces
43	None..................................	225.2	16.7	57.6	5.8	4.72
44	Copper Sulphate Solution, (1 oz. to 100 gals.)	200.2	18.4	55	7.7	4.89
45	Copper Sulphate Solution, (8 oz. to 100 gals.)	223.6	12.5	66.7	4.2	4.30
46	None..................................	153.5	17.5	126.8	5.8	4.86
47	Copper Sulphate Solution, (8 oz. to 100 gals) +Soap (1 lb. to 16 gals.).............	211.1	23.4	95.1	4.2	4.69
48	Copper Sulphate Solution, (2½ lbs. to 100 gals.) +Soap (1 lb. to 16 gals.).............	225.2	13.3	108.5	4.2	5.18
49	None..................................	208.6	20	99.3	0	4.85
50	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)....	355.4	20.8	30	2.5	6.06
51	Weak Bordeaux Mixture..................	391.3	11.7	51.7	0	6.54
52	None..................................	141.8	6.7	163.5	8.3	5.15
53	Cop. and Am. Carb.+Soap (1 lb. to 16 gals.)	247.8	21.7	125.9	1.7	5.61
54	Copper and Ammonium Carbonates.........	308.7	15	114.3	0	6.70
55	None..................................	91.8	15	145.1	12.5	4.93
56	Cop. and Am. Carb.+Soap (1 lb. to 32 gals.)	271.1	31.7	85.9	2.5	6.38
57	Mod. Eau Celeste+Soap (1 lb. to 32 gals.)...	305.3	14.2	86.7	2.5	6.24
58	None..................................	65.1	15	170.2	8.3	4.01
59	Modified Eau Celeste.....................	240.3	16.6	136	1.7	6.07
60	Mod. Eau Celeste+Soap (1 lb. to 16 gals.)...	276.6	20	73.4	3.3	5.28
61	None..................................	88.4	13.3	133.5	9.2	4.17
62	Weak Bordeaux Mixture+Molasses........	298.7	18.4	68.4	1.7	5.98
63	Wk. Bord. Mixt.+Soap (1 lb. to 16 gals.)...	196.9	22.4	110.1	9.2	5.12
64	None..................................	80.1	11.7	153.5	13.3	5.82
65	Weak Bordeaux Mixture..................	340.3	21.7	56.7	11.7	5.46
66	Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.).....	325.3	21.7	45	5	5.39
67	None..................................	113.4	13.4	173.5	15	4.07
68	Str. Bord. Mixt.+Soap (1 lb. to 8 gals.).....	385.1	20	43.4	3.3	5.04
69	Strong Bordeaux Mixture.................	427.1	26.7	23.3	2.5	5.44
70	None..................................	118.4	10	183.5	10	4.36
71	Very Wk. Bord. Mixt.+Soap (1 lb. to 32 gals.)	250.2	21.7	138.5	11.7	5.88
72	Very Wk. Bord. Mixt.+Soap (1 lb. to 16 gals.)	226.9	15.9	161.8	15	5.04
73	None..................................	114.2	13.4	111.7	11.7	2.80
74	Very Weak Bordeaux Mixture.............	265.2	16.7	106.8	10	4.69
75	Very Wk. Bord. Mixt.+Soap (1 lb. to 8 gals.)	220.2	16.7	103.4	8.3	4.01
76	Strong Bordeaux Mixture.................	265.2	21.7	25	0	5.16
77	None..................................	93.4	10.9	110.1	6.7	4.39

DAIRYING.

By J. L. HILLS.

Dairying is the main industry of the Vermont farmer. In recognition of this fact, the Experiment Station has always made the subject prominent in its work. Dairying, however, is taken in the widest sense of the word, to include not only the care and feeding of cows, and the handling of the product, but also crop raising, harvesting and preservation.

The results of the investigations of the year are grouped under the following heads:

I. Feeding Tests with Various Ensilages.
   1. Robertson Mixture vs. Corn Ensilage.
   2. Rye Ensilage vs. Corn Ensilage.
   3. Corn and Soja Bean Ensilage vs. Corn Ensilage.
   4. Ensilaged Peas and Oats, and Vetch and Oats vs. Corn Ensilage.

II. Records of the Station Herd for 1892 and 1893.

III. The Effect of Weather on the Quality and Quantity of Milk.

IV. Tests of Dairy Apparatus.

V. Churning Experiments.

VI. The Effect on the Character of the Milk of Feeding Bone Meal.

VII. The Effect of the Change from Barn to Pasture.

VIII. Ensilaging Soja Bean and Vetch.

IX. Miscellaneous Notes on Handling Milk.

X. Comparison of Varieties of Corn.

XI. Miscellaneous Fodder Crops.

I. FEEDING TESTS WITH VARIOUS ENSILAGES.

1. ROBERTSON MIXTURE VS. CORN ENSILAGE.

Indian Corn is the most servicable crop that can be grown for the winter feeding of the dairy, its pre-eminence being due to its heavy yield of dry matter per acre, as compared with other crops. It is not, however, of itself a complete food. It has a wonderful capacity for storing up starch, sugar, etc., but is less sucessful in gathering protein. The carbohydrates (heat producers) are in excess as compared with the protein or albuminoids (flesh formers) and a ration of corn alone is not well balanced. In order to "balance" the ration, it is necessary to add other food materials which are especially rich in albuminoids, such as cottonseed, linseed or gluten meals. If not thus balanced, the food ingredients already present are fed at a disadvantage, and a portion of their effect is lost.

Report of the Botanist.

L. R. Jones.

The results of the botanical investigations of the year are grouped under the following heads:

I. Experiments in Spraying Potatoes.
  1. Plan of the Experimental Plots.
  2. Potato Troubles as they Occurred in 1894.
  3. The amount of Gains from Spraying Potatoes in 1894.
  4. The Comparative Values of various Fungicides Tested.

II. Observations upon the Date of Planting Potatoes.

III. Experiments in the Prevention of Potato Scab.

IV. Experiments in the Prevention of Apple and Pear Scab.

V. The Occurrence of Oat Smut in 1894.

VI. Observations upon Grasses and Weeds.

VII. Some Studies upon Carnation Rust.

I. EXPERIMENTS IN SPRAYING POTATOES.

1. PLAN OF THE EXPERIMENTAL PLOTS.

Considerable attention was given again this year to the study of the various diseased conditions of the potato, and remedies for the same.

The experimental field planted with potatoes contained about one acre. It was somewhat irregular in shape, owing to the oblique direction of the road lying along one side of it. Without trying to figure minor irregularities, the following general plan of the plots is given.

GENERAL PLAN OF POTATO PLOTS SPRAYED EXPERIMENTALLY IN 1894.

NORTH. | SOUTH.

Plot A. Planted April 26.	Early Rose.
	White Star.
	Polaris.
Plot B. Planted May 4.	White Star.
	Polaris.

Plot C. White Stars, Planted May 15.	Plot D. Beauty of Hebron, Planted May 21.	
Plot E. White Stars. Planted May 21.	Plot F. White Stars, Planted May 21.	Plot G. Pride of Valley, Planted May 21.

In addition to this field there were excellent opportunities to study certain problems in neighboring potato fields where the conditions were different. The soil was a rather heavy clay loam. The land had been in grass for a dozen or more years previous. This sod was turned the preceding autumn, and the entire field except plot *B*, given a dressing of stable manure during the winter and early spring. A little commercial fertilizer was applied in the hill at time of planting. All planting was done in hills, to facilitate experimental work, since the rows thus running both ways favored the laying out of sub-plots for spraying. In all spraying experiments every third row was left unsprayed to serve as a check. It is believed that the errors arising from slight inequalities of the soil were thus satisfactorily corrected in most cases. The yields from these plots under the vairous experimental conditions are given in tabular form on pages 102–104.

2. POTATO TROUBLES AS THEY OCCURRED IN 1894.

In former spraying experiments upon potatoes at this Station, extending over five years, the main disease under consideration has been the late blight and the attendant rot (*Phytophthora infestans*). A secondary disease, quite important in some cases, has been the early blight caused largely by the fungus *Macrosporium Solanti.* Certain other troubles have been intimately associated with this last disease, notably the injuries of the flea-beetle. During the past season (1894) the prolonged drought of midsummer quite reversed the order of importance of these agencies. The Station plots remained practically free from the *Macrosporium* fungus.* Careful watch was kept for *Phytophthora*, but no evidence of its work was detected upon the tops. At digging time and during the winter a sufficient number of tubers showed the dry rot to prove that the fungus was present, and did a certain amount of damage, especially on plots E, F and G. Aside from this, however, the only apparent troubles upon the field were due to insects and to lack of water. The chief gains from spraying upon most of the plots were therefore attributable in our judgment, to the effects of the substances used upon the insects rather than upon the fungi. It is generally admitted that Bordeaux mixture has some unexplained beneficial effect upon plants in addition to its action toward either parasitic fungi or insects. In interpreting the results obtained some allowance must doubtless be made for this unknown factor. Even casual visitors to the fields, however, were convinced of the direct and important value of the Bordeaux mixture in checking work the of insects. Chief among these insect pests was the cucumber flea-beetle (*Crepiuodera cucumeris*). We described and figured this insect in our last report. So few potato growers have learned to recognize the nature of its injuries that an engraving from a potato leaf is here inserted, showing its work. (Figure 1).

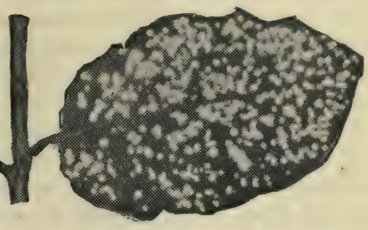


Fig. 1. Potato leaf eaten by Flea-beetles.

Fig. 2. Healthy potato leaf, sprayed with Bordeaux mixture.

The damage done by this beetle in 1893 was considerable, but nothing compared with its work in 1894. Its unusual abundance this year was doubtless attributable to the dry weather. Two clearly marked broods of the

*Although our own fields were entirely free from the Macrosporium there was as well developed a case of this trouble as we have ever seen in a field less than half a mile distant.

beetle were observed. The first brood appeared early in June, and after doing considerable damage disappeared about the middle of the month. The next brood appeared about July 20th in countless numbers and soon riddled the leaves of all unprotected plants. Some observations upon the action of Bordeaux mixture in checking this insect were made in 1893 and noticed in our last report.*

A continuation of this work had been planned for 1894 and systematic observations were at once begun to determine the exact value of the different substances used in repelling the flea-beetle. These examinations showed that there was a marked protective effect from the various forms of Bordeaux mixture and from modified Eau Celeste. The stronger the mixture the more evident this effect became, and soap appeared to add to the value of the mixtures. The rows sprayed with ammoniacal copper carbonate were but slightly protected. Paris green applied either in plaster or in water was not an effective remedy. In order to determine how complete was the protection given by the Bordeaux mixture two leaves were taken from the side† of each hill of a sprayed row and of an adjoining unsprayed row, which had, however, been poisoned with Paris green.

The actual number of holes per leaflet, from the unsprayed row was found upon counting to be 262, while from the sprayed row the average was but twelve. The condition of some of these leaves is strikingly shown in Figures 5 and 6. These results bear out completely the conclusions of last year and justify the claim that the Bordeaux mixture is the best practical remedy known for the flea-beetle as it occurs upon potatoes.

These observations were made on Plots *A* and *B* especially. The flea-beetles, of course, attacked all parts of the field indiscriminately, but upon the later planted plots the plants were still in vigorous growth and so suffered less from the attack of these insects. None of these late plots had as yet been sprayed. Expecting that the blight might soon appear, portions of these late plots were sprayed August 1st.

About this time the last of the hay crop was removed from the adjoining fields. Thereupon the grasshoppers migrated in large numbers from this hay field and settled especially upon these younger potato-plants. Here again as with the flea-beetle, the Paris green did not seem sufficient to check them. Probably this was because they did their most serious damage by eating the stems and the petioles of the leaves where but little poison was present. The appearance of the mutilated plants is shown in Figure 8. Fortunately the Bordeaux mixture seemed equally as offensive to them as it had to the flea-beetles. The result was that before the last of August the contrast between the sprayed and unsprayed rows of these later potatoes was almost as marked as it has been in seasons when the blight has swept over

*Seventh Report Vermont Experiment Station 1893, page 50.

†They were taken about midway between base and top, since the lower (older) leaves had been somewhat eaten by the beetles of the first brood and many of the upper (younger) leaves had developed since the spraying was done.

the field. The grasshoppers had cut off so many leaves that the plants were all dead upon the unsprayed rows, while the adjoining sprayed rows were comparatively thrifty. The appearance of the field on August 31 is shown in Figure 9.

Here again all the difference should not be attributed to the work of the grasshoppers. Some was due to the flea-beetles, some doubtless to unperceived fungus troubles and some to the unexplained beneficial action of Bordeaux mixture. Careful observations in the field from day to day left no doubt in our minds, however, that the greater part of the difference was due to the action of the mixture as a deterrent against the grasshoppers.

The actual damage to the crop by the flea-beetles and the grasshoppers was much aggravated by the dry weather, since the leaves mutilated by the insects soon shriveled and died. The Bordeaux mixture and some of the other fungicides in less degree thus served indirectly to aid the plants considerably in withstanding the drought.

3. THE AMOUNT OF GAINS FROM SPRAYING POTATOES IN 1894.

When the late blight and rot are prevalent the gains from spraying in Vermont are often enormous. In many cases our crop was doubled and even trebled by the application of Bordeaux mixture during 1892 and 1893. No such large gains can be hoped for in a dry season like that of 1894. Indeed, it was hardly expected at midsummer, that the gain would be sufficient to equal the cost of the applications. The development of the insect troubles during July and August, and the slight occurrence of the late blight in September gave the fungicides opportunity to prove their worth, as will be seen from the following summary of the results. These figures are abstracted from the fuller tabular statements of results given at the close of this article.

GAINS FROM SPRAYING POTATOES WITH THE BORDEAUX MIXTURE, 1894.

Variety.	Date of Planting.	No of times Sprayed.	Dates of Application.	Yields in Bushels per Acre. Sprayed.	Yields in Bushels per Acre. Not Sprayed.	Gain in Bushels.	Gain per cent.
White Star.......	April 26	3	June 16	323	251	72	29
Polaris	"	3	July 17	213	190	23	12
Early Rose.......	"	3	Aug. 30	190	146	44	30
White Star.......	May 4	2	July 18	201	166	35	21
Polaris...........	"	2	Aug. 30	164	135	29	21
Beauty of Hebron.	May 15	1	Aug. 1	147	124	23	19
Beauty of Hebron.	May 21	2	Aug. 1-31	168	150	18	12
White Star.......	"	1	Aug. 1	253	198	55	28
Pride of Valley...	"	1	Aug. 1	228	180	48	27

These gains, while not large, much exceed the cost of spraying and fully demonstrate that the use of the Bordeaux mixture upon potatoes is a profitable thing, even in exceptionally dry seasons like the last one.

4. THE COMPARATIVE VALUES OF VARIOUS FUNGICIDES UPON POTATOES.

This work forms a continuation of our experiments along the same lines in previous years. The conditions of weather during 1894 were so peculiar that the results are especially valuable as a supplement to previous experiments in so far as they concern the fungicides tested in seasons when the rainfall was greater. This applies to *a*, *e*, *f* and *g* below. In the case of the tests undertaken now for the first time (especially *b*, *c* and *d*) the results may be quite different in a wetter summer, and positive conclusions from them should be deferred until experiments under such conditions have been made.

The leading points of these experiments were to determine the relative values of :

a. Stronger and weaker Bordeaux mixture.
b. Bordeaux mixture in the form of a dry powder.
c. Bordeaux mixture which has stood some time after preparation.
d. Bordeaux mixture made by the potassium ferrocyanide test.
e. Modified eau celeste.
f. Ammoniacal copper carbonate (Delaware formula).
g. Soap as added to liquid fungicides.

a. The relative values of the Stronger and the Weaker Bordeaux Mixtures.

The stronger mixture consisted of one pound of copper sulphate and one pound of lime to five gallons of water. The weaker was exactly one-half this strength. In all cases where a careful comparison could be made the stronger mixture gave a little larger gains than did the weaker; for example in Plot *A* the strong mixture gave a yield of 260 and the weak of 256 bushels per acre. This difference was less marked than it has been in previous years, doubtless owing to the dryer weather of the present summer. The question arises whether the additional gain from the use of the stronger mixture is sufficient to repay the additional cost

If these applications are made using 450 gallons per acre, the cost of the chemicals becomes a matter of some importance. If the stronger mixture is used it requires about ninety pounds each of copper sulphate and lime, costing about $7. If the weaker mixture is used the cost is reduced one-half. The gain from the stronger mixture, noted on Plot *A* would not repay this extra cost. It should be remembered, moreover, that the stronger the mixture, the greater the clogging of the nozzles and the subsequent inconvenience of using the mixture. In general, we believe an intermediate strength would be found most profitable, using about one pound of the copper sulphate to seven and one-half gallons of water, or about six to seven pounds for each barrel of the mixture.

b. The relative value of Bordeaux mixture applied as a dry powder.

The inconvenience of preparing the Bordeaux mixture and the expense of pumps with which properly to apply it have been serious obstacles in its introduction into general use. Any device that will successfully obviate these

difficulties will therefore be gladly welcomed. During the past year an attempt has been made to do this by applying the mixture in the form of a very fine dry powder. The firm of Leggett & Brothers, of New York, have sent out such a powder under the name of "Fungiroid," and as this has been advertised extensively in Vermont, a large number of inquiries have been received concerning its value. Careful tests of this Fungiroid were planned, and also of a similar powder prepared by ourselves. In preparing this the mixture was made by the ferrocyanide test. The precipitate was then thoroughly dried and very finely powdered by passing between regular mill stones, We shall speak of this as Bordeaux powder. The powders were applied with Leggett's dry powder gun.

In order to give the powders the best possible chance to adhere, the plants were, in most cases, sprinkled with water just before applying them. On Plot *A* three applications of clear Bordeaux powder were made at same dates as regular sprayings. The powder was applied very freely, using at the rate of fully forty pounds per acre* each application. The yield under this treatment, as shown in Table 1, was 243 bushels per acre, while the adjoining rows sprayed with weak Bordeaux mixture yielded 256 bushels per acre. A portion of the later planted potatoes was staked out as Plot *J*, for a more extended trial of both the Fungiroid and the Bordeaux powder in various degrees of dilution. Unfortunately, different portions of this plot suffered unequally from the drought owing to some differences in the slope of the land. The yields as shown in Tables X and XI are not therefore a very safe source from which to draw conclusions. The general nature of these results, together with the appearance of the growing plants as noted during September make it clear that the dry Bordeaux powder is a fungicide of considerable merit and worthy of further careful trial. At present, however, we do not feel justified in recommending it as a safe substitute for the wet form of the mixture. A comparison of Tables X and XI would indicate that the home-made powder was superior to the Fungiroid, but until there has been opportunity to test them again under more favorable circumstances it is not just to draw decided conclusions.

c. What is the relative value of Bordeaux mixture which has stood some time after being made.

Does Bordeaux mixture deteriorate upon standing, and, if so, to what degree? If a quantity of the mixture remains at the close of one spraying, is it advisable to keep it till the next application is to be made and then use it, or should it be thrown away and only the freshly prepared mixture used? These and similar questions are often asked by those using the mixture. As a practical test of the value of the mixture which has stood thus a quantity was prepared in June, and certain rows upon Plot *A* were sprayed with this old mixture during July and August, As will be seen by referring to yields

*The first application was considerably heavier than this; the others approximately this amount

given in Table I., this mixture proved considerably inferior to that freshly prepared as used, the yield where this old mixture was used being 229 bushels per acre as compared with 260 bushels per acre where the freshly prepared mixture was employed. It was planned to continue similar tests upon the potatoes sprayed later, but the prolonged drought defeated these plans and left us with only the results from this one plot upon which to base conclusions.

d. What is the relative value of Bordeaux mixture made by the potassium ferrocyanide test?

Bordeaux mixture, as usually made, contains from two-thirds of a pound to one pound of lime for each pound of copper sulphate. The lime is used to precipitate the copper. It is some trouble to weigh out the lime in making the mixture, and to avoid this the use of the ferrocyanide test has been proposed. This test consists in adding a few drops of a solution of ferrocyanide of potassium to the mixture. If there is not enough lime in the mixture this added solution will at once turn brick red, but if enough lime has been added there will be no change of color. A series of careful trials showed that about one pound of the fresh lime used in these experiments will neutralize three pounds of copper sulphate, as shown by this test. The question at once arises, is this mixture, containing only about one-third the amount of lime as efficacious as the mixture made by the old formula? A comparative test of both the strong and the weak mixtures made by the two methods was made on Plot *A*. In both cases the mixture made with the excess of lime, i. e., by the regular formula, gave the better results. The yields from these tests were as follows:

Strong	Bordeaux	mixture,	regular formula,	260 bushels per acre.
"	"	"	ferrocyanide test	241 " " "
Weak	"	"	regular formula	256 " " "
"	"	"	ferrocyanide test	242 " " "

Similar evidence was obtained from some of the later planted potatoes. It seems clear, therefore, that under the conditions which existed last summer, the mixture made by the test was inferior to that containing an excess of lime. If this is the case in a dry summer, we should expect it to be even more so in one when the normal amount of rain falls, since the lime doubtless makes the mixture more adhesive. We advise, therefore, that in preparing the mixture by the ferrocyanide test an excess of lime be added after the mixture ceases to respond to the test, It will be an easy matter to add by guess after the mixture is neutralized approximately as much more lime as has already been used. A mixture can thus be made which possesses the virtues of the old method and still avoid the trouble of weighing the lime.

e. What is the relative value of Modified Eau Celeste?

This fungicide is made by dissolving four pounds of copper sulphate in ten gallons of water, then adding five pounds of sal soda. The precipitate thus

formed is dissolved by the addition of three pints of strong ammonia, and the whole diluted with water to forty-five gallons. A perfectly soluble fungicide is thus prepared which will retain its strength indefinitely if kept sealed. In our experiments with this in former years it has always proved somewhat inferior to the Bordeaux mixture, but was by far the best of the soluble fungicides. The results this year justify the same conclusions. The results from Table I are as follows:

Strong Bordeaux mixture	260 bushels	per	acre
Weak Bordeaux mixture	256 "	"	"
Modified Eau Celeste	240 "	"	"

The modified eau celeste is more expensive than the Bordeaux mixture, and the superior results from the mixture will well repay the additional trouble of making and applying it. We used double strength modified eau celeste upon one row of potatoes, and applied it freely with a watering pot. The foliage showed no signs of injury from this unusual application.

f. What is the relative value of Ammoniacal Copper Carbonate?

This is the most convenient fungicide ever tried at this Station. In comparative tests of it made during 1892 and 1893, it proved disappointingly worthless, however. The method then used in its preparation was to dissolve five ounces of copper carbonate in three pints of strong ammonia and dilute to forty-five gallons. Bulletin 22, of the Delaware Station, which appeared early in 1894, recommended a new method of preparing this fungicide by which its strength could be increased. This method differed from the old one in diluting the ammonia with from seven to eight volumes of water before adding the copper carbonate. In the hope that this method might so improve the fungicide as to make it of practical value in spraying potatoes it was added to the list for trial again in the experiments of 1894. The results as shown by the yield in Table I give no further encouragement, however. The yields were as follows:

Weak Bordeaux mixture	256 bushels	per	acre
Ammoniacal Copper Carbonate	163 "	"	"
Check row (untreated)	162 "	"	"

The appearance of the plants during the summer agreed substantially with the above figures, and we feel satisfied that this fungicide is so nearly valueless as to be unworthy of further trial on potatoes.

g. What is the value of soap when added to Fungicides?

Trials of soap added to Bordeaux mixture and other fungicides in 1893 led to the conclusion that its value was at least doubtful. Further trials along the same line were made in 1894. The results as shown in Table I are entirely against it when used with the stronger fungicides. These results following upon those of 1893 fully warrant the conclusion that the soap on the whole is more liable to detract from the value of the fungicides than to add to it. The expense and inconvenience attending its use are, moreover, considerable. It is not considered worthy, therefore, of further trial upon potatoes.

TABLES SHOWING RESULTS OF SPRAYING POTATOES WITH VARIOUS FUNGICIDES DURING 1894.

TABLE I.—Plot A, White Star, Polaris and Early Rose potatoes, planted April 26. Applications made on June 30th, July 18th and August 30th, unless otherwise stated.

TREATMENT.	YIELDS.
1. Strong Bord. Mixt., applied July 18 and August 30	246 bushels per acre
2. Gypsum dusted on leaves	199 " "
3. Strong Bordeaux Mixture	260 " "
4. No fungicide	206 " "
5. Strong Bordeaux Mixture with Ferrocyanide test	241 " "
6. Strong Bord. Mixt., allowed to stand after made	229 " "
7. No fungicide	174 " "
8. Strong Bord. Mixt., Ferrocyanide test with soap	253 " "
9. Weak Bordeaux Mixture, Ferrocyanide test	242 " "
10. No fungicide	194 " "
11. Weak Bordeaux Mixture	256 " "
12. Bordeaux Powder, (heavy application)	243 " "
13. No Fungicide	196 " "
14. Modified Eau Celeste	240 " "
15. Modified Eau Celeste with soap	213 " "
17. No fungicide	162 " "
18. Ammonical copper carbonate (Delaware formula)	163 " "
19. Ammonical copper carbonate with soap	203 " "
20. No fungicide	187 " "

TABLE II.—Plot B, White Star and Polaris potatoes, planted May 4th. Two applications made, July 18 and August 31.

TREATMENT.	YIELD.
1. Average yield of all rows not sprayed	147 bushels per acre
2. Strong Bordeaux Mixture with soap	201 " "
3. Weak Bordeaux Mixture	186 " "
4. Weak Bordeaux Mixture, Ferrocyanide test	158 " "

TABLE III.—Another portion of same piece as plot B, sprayed only once, August 1.

TREATMENT.	YIELD.
1. Average of all rows not sprayed..................	135 bushels per acre
2. Weak Bordeaux Mixture........................	155 " "

TABLE IV.—Plot C, Beauty of Hebron potatoes, planted May 15th. Sprayed only once, August 1.

TREATMENT.	YIELD.
1. Average of rows not sprayed	123½ bushels per acre
2. Weak Bordeaux Mixture........................	147 " "

TABLE V.—Plot D, Beauty of Hebron potatoes, planted May 21, north end, sprayed twice, July 6th and August 1st.

TREATMENT.	YIELD.
1. Average of rows not sprayed......................	146 bushels per acre
2. Sprayed with weak Bordeaux Mixture..............	161½ " "

TABLE VI.—Plot D, south end sprayed twice, August 1st and 29th.

TREATMENT.	YIELD.
1. Average of rows not sprayed......................	155 bushels per acre
2. Sprayed with weak Bordeaux Mixture..............	174 " "

TABLE VII.—Plot E, White Star potatoes, planted May 21, sprayed once, August 1st.

TREATMENT.	YIELD.
1. Average of rows not sprayed......................	198 bushels per acre
2. Sprayed with weak Bordeaux Mixture..............	253 " "

TABLE VIII.—Plot G, Pride of the Valley potatoes, planted May 21, sprayed once, August 1st.

TREATMENT.	YIELD.
1. Average of rows not sprayed	180 bushels per acre
2. Sprayed with weak Bordeaux Mixture	228 " "

TABLE X.—Plot F, White Star potatoes, planted May 21, one application made August 6th. (Soil not very uniform, hence these results are not altogether reliable.)

TREATMENT.	YIELD.
1. Weak Bordeaux Mixture	169 bushels per acre
2. Leggett's fungiroid, heavy application	167 " "
3. Ditto, mixed with equal parts of flour	153 " "
4. Ditto, 2¼ oz. water, 1 gallon	140 " "
5. Ditto, mixed with 5 parts flour	118 " "
6. Check rows, no fungicide	112½ " "

TABLE XI.—White Star Potatoes, planted May 21. One application made August 6th. (Soil not very uniform.)

TREATMENT.	YIELD.
1. Home made "Bordeaux Powder," heavy application	223½ bushels per acre
2. Bordeaux Powder with equal parts flour	207 " "
3. Bordeaux Powder with five parts flour	207 " "
4. Bordeaux Powder, 2¼ oz. in water, 1 gal	204 " "
5. Weak Bordeaux Mixture	200 " "
6. Check rows, no fungicide	163½ " "

II. OBSERVATIONS UPON THE DATE OF PLANTING POTATOES.

Any practical study of the diseases of the potato in Vermont must include a consideration of the date of planting, and consequently of the maturity of crop. As a result of observations and experiments extending through the years of 1890–93, the conclusion was published in our last Report that when one is working merely for the largest crop with the least possible work in protecting it from insects and diseases, he will do best to use a vigorous variety of medium or late potatoes, and delay the planting until about May

10th to 20th. The reason for this is obvious when the usual conditions of rainfall in Vermont are considered. Potatoes planted in the last of April will form their tubers during the period extending from the last of June to the first of August, the exact time varying with the variety, that is, whether it is an early or late one. Now, potato tubers contain about eighty per cent water, the remainder is starch, and in the manufacture of this starch a large additional amount of water is consumed. During the period of tuber formation the potato plant therefore needs its largest supply of water. As a matter of fact, however, the period from the last of June to the first of August is usually the driest portion of our summer. By planting potatoes the last of April, therefore, we force them to form tubers when the water supply is least, and as a result we rarely get a full crop. In fact, if there are serious attacks of insects or of fungus diseases during this period, the earlier planted potatoes die or "ripen prematurely," giving a small yield of imperfectly ripened potatoes. The only compensation is that these early potatoes, dying thus in the dry weather, largely escape danger from the late blight and rot. Before a remedy for this disease was known most successful potato growers preferred to plant early and thus be sure of the smaller yield, rather than to plant later and run the risk of serious loss from the blight and rot. By the use of Bordeaux mixture later potatoes may now be perfectly protected against disease during the warm, most weather of August and early September. By planting May 10th to 20th. the later varieties form their tubers during this period, which is usually the most favorable of all the summer, and as a result very large yields become possible. For example, in 1893, Polaris potatoes planted April 29, under the best treatment of spraying, etc., yielded 295 bushels per acre; while Polaris potatoes taken from the same bin and planted May 9, with the same treatment, yielded 378 bushels per acre. White Stars, planted May 20, yielded 400 bushels per acre. The conclusion, therefore, based on the experiments of 1890-93, was that the later planting is the most profitable. In 1894, however, results were exactly reversed. Our plantings of the same varieties extended from April 29 to May 23. The largest yields came from the earliest planted, the smallest yields from the latest, other conditions being equal. Thus White Star potatoes planted April 26th, yielded 323 bushels per acre, while the same variety planted May 21st gave only 253 bushels. Looking for the reasons, they are easily found. To begin with, the first week of May was the warmest of the month. The early planted potatoes got rooted and started under favorable conditions. About May 20 cold, wet weather set in and lasted for two weeks. The later planted potatoes lay in the ground without starting during this time, and many of them rotted before or immediately after sprouting. Immediately following this in June a protracted drought began which continued into September with but slight and infrequent rainfalls. Of course, the late planted potatoes, starting under unfavorable conditions, never fully recovered, and they made a poor growth throughout the summer. When

the attacks of the flea-beetles and grasshoppers came in July and August the plants which were mutilated by them very generally succumbed to the combination of insect attacks and dry weather. The early planted potatoes made sufficient growth in early summer to more fully shade the ground and developed sufficient root system to carry them more successfully through these disastrous conditions into September, when the welcome rains came. Where they were protected by Bordeaux mixture the majority of them lived until late fall. There was no hard frost in Burlington until November, and some of the more vigorous plants still held a good portion of their leaves green until this date. Polaris potatoes, planted April 27, lived past the middle of October, nearly six months from planting till death, and White Stars planted on the same date lived into November, or over six months from date of planting. This is a remarkable record for potato plants in Vermont. Usually these same varieties of potatoes when planted in April have died in August or by September first. Apparently, the peculiar weather conditions of May to July retarded their maturity and induced such a gradual formation of tubers that they persisted longer than usual. Probably, also, the entire absence of the early blight from the field during the summer conduced to the same result. To conclude, then, the date of planting should depend upon whether one is prepared to spray, and also upon the conditions of weather which are to be expected. In our judgment, the season of 1894 was such an exceptional one that the results should not lead to any modifications of our former advice, and that for the largest yield in Vermont medium or late planting, combined with spraying, should be practiced.

III. EXPERIMENTS IN THE PREVENTION OF POTATO SCAB.

Potato scab ranks second only to the late blight as an enemy to the highest success in potato culture in Vermont. The primary cause of the scabbing of potatoes in this section of the country is a fungus growth. This fungus is propagated by means of spores. The details of this matter have been discussed in former publications and it is only necessary to recall here that the two chief sources of danger to the crop are from the presence of these spores either upon the seed that is to be used or in the soil before the seed is planted. Certain western investigators, notably Professor Bolley of the North Dakota Experiment Station, have been successful in preventing the scab upon potatoes by disinfecting the seed potatoes before planting with a solution of corrosive sublimate.*

*Following are practical directions for so disinfecting them: Purchase from a druggist two ounces of corrosive sublimate (bichloride of mercury.) Empty this into two gallons of hot water in a wooden or earthen vessel, and allow it to stand over night. Place in a barrel, or wooden tub, thirteen gallons of water, then pour in the two gallon solution. Stir thoroughly to insure equality of solution before using. Select as fair seed potatoes as possible, rinse off the old dirt and immerse them in the solution one hour and thirty minutes. At the end of this time turn off the solution into another vessel. The solution may thus be used a number of times if wished. After drying, the potatoes may be cut and planted as usual. Corrosive sublimate is an active poison and should be handled with care. The solution here recommended is dangerous only if taken into the stomach. Potatoes treated and unused should be destroyed.

There can be no doubt that under the conditions of the experiments of these investigators the practical value of this method of disinfecting seed potatoes has been thoroughly demonstrated. They have proved that when seed is thus treated a clean crop is insured, *providing* the soil is clean also. Unfortunately much of the best potato land in Vermont appears already to be contaminated with the germs of this scab fungus. The demonstration of the exact practical value of this corrosive sublimate treatment as applied to our conditions is yet largely to be made. As a contribution to this end a series of plots were laid out in a portion of the potato field in 1894. The land used had been in grass for at least fifteen years previous, and commercial fertilizers alone were used upon it. The plots lay as follows:

1. Polaris, Scabby. No treatment.	5. Polaris, Smooth. No treatment.	9. Polaris, Scabby. No treatment.
2. Polaris, Scabby. Disinfected.	6. Polaris, Smooth. Disinfected.	10. Polaris, Smooth. Disinfected.
3. White Star, Scabby. No treatment.	7. White Star, Smooth. No. treatment.	11. White Star, Scabby. No treatment.
4. White Star, Scabby. Disinfected.	8. White Star, Smooth. Disinfected.	12. White Star, Scabby. Disinfected.

It will be seen that the twelve plots were divided into four series.

1st series: Planted with smooth seed, no previous treatment. (Plots 5 and 7.)

2d series: Planted with smooth seed, disinfected with corrosive sublimate before planting. (Plots 6 and 8.)

3d series: Planted with scabby seed, no previous treatment. (Plots 1, 3, 9, 11.)

4th series: Planted with scabby seed, disinfected before planting. (Plots 2, 4, 10, 12.)

The plots upon which the smooth seed were used (Plots 5 and 8) lay upon a slight rise of ground so that the drainage was from these plots toward those upon either side where scabby seed was used. Precautions were taken in cultivation to carry the soil from one plot to another as little as possible.

Unfortunately the wire-worms were very abundant and attacked the tubers so badly as to make exact sorting of the crop upon the basis of its scabbiness very difficult. The following are the general results: There was but little difference in scabbiness between the crops from the first and the second series. Many potatoes from each were slightly scabby,* but none sufficiently so to make them unsaleable.

*This same condition of slight surface scabbiness existed over most of the remainder of our potato plots. These were all planted with disinfected seed, but stable manure was used upon them.

This probably indicates that the scab germs were present in the soil before the seed was planted, although not so abundant as to seriously harm the potatoes. It indicates also that the smooth seed was in this case, practically free from the scab germs, although it must not be inferred that this is always the case. The contrast between the plots of the third and fourth series, that is, between those where the scabby seed was used with and without disinfection, was very marked as is apparent from the following statement of the results:

TABLE SHOWING YIELDS OF TUBERS OF MARKETABLE SIZE, IN OUNCES, AND THE CONDITION OF THESE AS TO SCAB.

Variety of Potato.	Condition of "seed."	Treatment of "seed" before planting	Yields in Ounces. 1. Total yield of tubers of marketable size.	2. Unmarketable because of the scab.	3. Total yield of marketable tubers.	4. Condition of these marketable tubers. Free from scab.	Slightly Scabby.
Polaris	Scabby.	None.	1,143	209	934	298	636
Polaris	Scabby.	Disinfected.	1,368	14	1,354	884	470
Wh. Star	Scabby.	None.	1,307	306	1,001	501	500
Wh. Star	Scabby.	Disinfected.	1,591	None.	1,591	1,310	281

As shown in column two of the yields there was practically no loss of saleable tubers from scab where the seed was disinfected, while there was an average loss of 21 per cent where the seed was planted with no treatment. As further shown in column one, there was a decided increase in total yield from the disinfected seed, amounting on the average to over 20 per cent. The total yields of marketable potatoes (column three) was increased over fifty per cent as a direct result of disinfecting the tubers.

Of course in such a case as this where all the seed potatoes were scabby the gain exceeds what would be obtained in ordinary practice, but it nevertheless emphasizes in a striking manner the practical value of disinfecting seed potatoes where the scab is troublesome. The process of disinfecting them involves but slight labor and an expense of but a few cents for corrosive sublimate.

IV. EXPERIMENTS IN THE PREVENTION OF APPLE AND PEAR SCAB.

The value of Bordeaux mixture as a remedy for apple and pear scab has been demonstrated beyond question. Spraying experiments begun six years ago at the Michigan and Wisconsin Experiment Stations, have been continued with a greater or less degree of success in various states each year since. Reports of satisfactory results in checking the scab on both pears and apples at this Station will be found in Bulletin 28, and in the Report for 1891 and the work has been repeated since with similar results. Vermont orchardists have been slow, however, to test for themselves the value of spraying either against insect or fungus pests. In New York, for example, this is becoming the general practice, while in Vermont it is the exception to spray orchards. The explanation is simple. On most Vermont farms the orchard is secondary to other interests, especially to the dairy. The average farmer has his time so fully occupied with other duties that he is loth to undertake a new one until he is convinced that it will bring a sure reward. Moreover, Vermont, as a State, has climatic conditions which are quite different from those of the more southern and western states, and many of our best orchardists, realizing this, have been slow to adopt practices found successful in distant localities. Led by these considerations we planned to make another thorough test of the value of spraying apples and pears in 1894.

In order to give the results of the work as much practical value as possible the experiments were made in South Hero, in Grand Isle County, one of the finest orchard sections of the State. After visiting a large number of orchards, the one on the farm of Mrs. Lydia M. Root was selected as best suited to the work. Our thanks are due Messrs. T. L. Kinney, Stephen Gordon and L. B. Phelps, for valuable advise and assistance in selecting the orchard and conducting the experiments. This orchard is one of the largest in the State and includes all of the standard varieties of fruit grown on Grand Isle, mostly apples in bearing. It has remarkably uniform soil conditions. The trees of the main portion of the orchard are about 25 years old. All the trees were sprayed in one row extending through the heart of this portion of the orchard, and in addition a number of scattering trees of certain varieties of apples and of Flemish Beauty pears. These scattering trees were selected, following the advise of the above named orchardists, from those varieties especially subject to scab. In another portion of the orchard were two rows of young Fameuse trees, just in good bearing. All the trees in one row of these were sprayed, the other row being left as a check. Altogether about 80 trees were under observation in the experiment, 40 being sprayed and 40 unsprayed.

TABULAR SUMMARY OF THE SPRAYING AND WEATHER.

No. and date of spraying.	*Mixture used.*	*What trees were Sprayed.*	*Condition of trees.*	**Meteorological conditions at time of and following the application.*	
				Rain-fall.	Temperature.
1st application, Apr. 23	Bordeaux.	All trees included in the experiment.	Leaf buds swollen.	Only trace during next ten days.	Warm for time of year.
2d application, May 4.	Bordeaux and Paris green.	All trees included in the experiment.	Leaves expanded.	.85 inch May 5-7, .33 inch May 18-19.	Cool for time of year.
3d application, May 21	Bordeaux and Paris Green.	All but one Fameuse tree.	Last blossoms just falling.	.77 inch May 23-5. 1.41 inch May 28-31.	Cold for time of year.
4th application, June 2.	Bordeaux and Paris Green.	All trees included in the experiment.	Fruit size of marbles.	.63 inch June 1-5.	Cool until about June 8
5th application, June 16	Bordeaux.	Only two-thirds of the trees.†		.67 inch June 27.	Normal for this season.
6th application, July 3.	Bordeaux.	Only one-fifth of the trees.‡			
7th application, July 26	Bordeaux.	3 Fameuse trees.			

Scab spots were found in abundance on both leaves and fruit of the unsprayed trees as early as June 1st, but none could be found on the sprayed trees.

The difference became still more marked as the summer advanced, the scab spots enlarging and new ones developing on the unsprayed trees, while the sprayed trees remained practically free from disease.

* Records made at Burlington, but practically applicable to South Hero.

† Including all varieties under test.

‡ Including only varieties most subject to scab, viz: Fameuse and Winter Strawberry apples, and Flemish Beauty pear.

A glance at the above table shows that while some of the trees were given only four applications, others were sprayed five, six and even seven times. Examinations made during the summer and at the time of harvest failed to show any advantage from the extra applications.

Examinations of the trees in mid-summer showed that the sprayed trees would make a profitable return for this extra care. In order to have visible proof of this fact for the State and the Inter-State fair exhibits in September, 200 apples were picked from a sprayed, and the same number from an adjoining unsprayed tree of the same variety. In each case pains were taken to select trees standing close together, of the same age and equally loaded with fruit. The fruit was taken in all cases from the east side of the tree, picking *all* the fruit within reach from the ground. In this way samples were secured which represented fairly the relative conditions of sprayed and unsprayed trees of each of the following varieties: Flemish Beauty pear (sprayed tree had 4 applications), Fameuse apple (4 applications), Winter Strawberry and Yellow Bellflower apples (5 applications each). The fruit from each tree was then sorted by Mr. T. L. Kinney, one of the most expert judges of fruit in the State, into first, second and third classes on the regular market basis.

The results were as follows:

	1st class.	*2d class*	*3d class.*
Flemish Beauty Pear, sprayed,	94 per cent.	6 per cent.	0 per cent.
" " " not sprayed,	55 "	43 "	2 "
Winter Strawberry Apple, sprayed,	65 "	24 "	11 "
" " " not sprayed,	31 "	45 "	24 "
Fameuse Apple, sprayed,	46 "	28 "	26 "
" " not sprayed,	27 "	29 "	44 "
Yellow Bellflower Apple, sprayed,	47 "	42 "	11 "
" " " not sprayed,	39 "	38 "	23 "

The condition of the fruit from the sprayed and unsprayed Flemish Beauty pear trees is shown in Figures 3 and 4 which are from photographs of this fruit as exhibited at the State Fair at White River Junction and at the Inter-State Fair at Burlington.

The actual profit from spraying was even greater than might appear from a first glance at the above figures. The market value of the No. 1 apples as sorted were just twice those of the No. 2, while the No. 3, or "cider" apples were unsalable.

In the case of the pears, the difference becomes even greater, since the first-class fruit from the sprayed trees was valued by one buyer as worth twice as much as that graded as first-class from the unsprayed tree. Another buyer valued it as worth one and one-half times as much. The seconds of the pears are again worth only one-half as much as the first-class fruit.

Moreover, the fruit from the sprayed trees averaged larger than that from the unsprayed trees.

Taking these elements into consideration and calculating the market values of the sprayed and unsprayed fruit, they become as follows :

Flemish Beauty Pears.

Sprayed, 100.

Not sprayed, 47.

Winter Strawberry Apples.

Sprayed, 100.

Not Sprayed, 63.

Fameuse Apples.

Sprayed, 100.

Not sprayed, 58.

Yellow Bellflower Apples.

Sprayed, 100.

Not sprayed, 83.

The fruit on the remaining trees was picked and sorted in the same way as soon as mature. The condition of the fruit on the entire pear trees showed even greater gains from the spraying than did the above samples taken from the lower branches. With the apples, however, owing to the dry weather, the fruit of the upper branches of even the unsprayed trees was exceptionally fair and the gain from spraying were therefore less marked. The following are the results from the more important varieties:

Variety.	*Relative Values of the Fruit.*		*Gain from Spraying.*
	Sprayed Tree.	Unsprayed Tree.	
Flemish Beauty Pear............	100	46	117 per cent.
Fameuse Apple............	100	79	27 " "
Yellow Bellflower Apple.........	100	81	24 " "
R. I. Greening Apple............	100	82	23 " "

Another decided benefit from the spraying which is not shown in the above estimate, was in the improved keeping quality of the sprayed fruit. Two barrels were filled with No. 1 Flemish Beauty pears, one with fruit from a sprayed tree, the other with fruit from an unsprayed tree. These barrels were placed side by side in a cool cellar. The unsprayed fruit soon softened and began to decay, while the sprayed fruit kept well, until fully three weeks after the last of the unsprayed fruit had decayed.

The amount of gain from spraying was of course wholly dependent on the amount of the disease present. Owing to the remarkably dry weather there

SHOWING AVERAGE CONDITION OF FRUIT FROM SPRAYED AND UNSPRAYED TREES. (See details on page 87.)

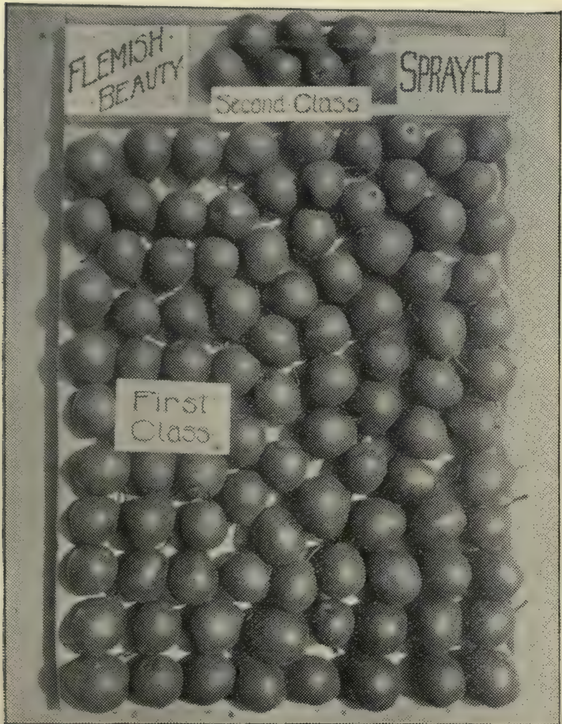


Figure 3. One hundred Flemish Beauty pears from sprayed tree showing relative amounts of 1st and 2d class fruit.

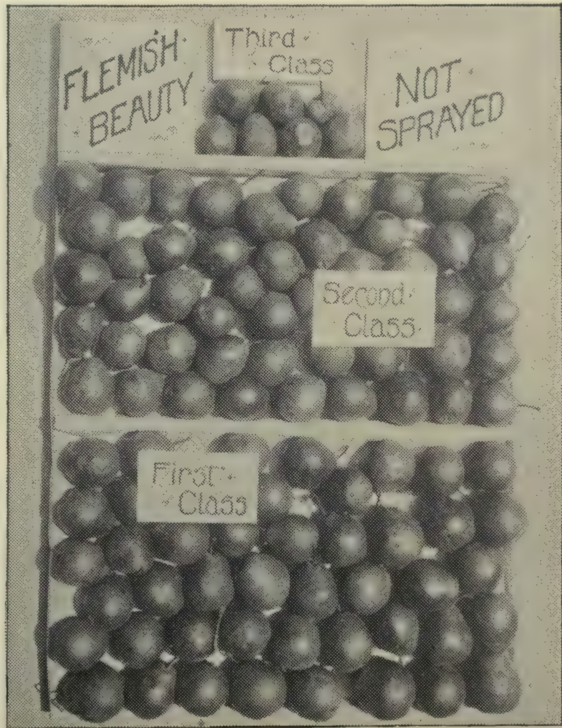


Figure 4. One hundred Flemish Beauty pears from adjoining unsprayed tree showing relative amounts of 1st, 2d and 3d class fruit.

Figure 5. A perfect Potato Leaf, sprayed with Bordeaux mixture. (See page 95.)

Figure 6. A Potato Leaf showing holes eaten by Flea-beetles. (See page 95.)

Figure 7. A healthy hill of potatoes. Sprayed with Bordeaux mixture.

Figure 8. Not sprayed. The upper leaves cut off by Grasshoppers.

SPRAYED. NOT SPRAYED.

Figure 9. From photograph of Station potato plots made August 31. Showing beneficial effects of Bordeaux mixture chiefly from checking the Grasshoppers. (See page 97.)

was, as already noted, less scab than usual upon any of the fruit. The Bordeaux mixture preserved the sprayed fruit almost perfectly free from scab. In order to determine the results in this regard more exactly, the entire crop of fruit from one sprayed and a corresponding unsprayed tree of each variety was examined with the following results :

TABLE SHOWING EFFECTS OF BORDEAUX MIXTURE IN PREVENTING THE SCAB SPOTS ON THE FRUITS.

Variety.	*No. of Apples or Pears.*		*Corresponding per cent.*	
	Scabby	Smooth	Scabby.	Smooth.
Flemish Beauty Pears not sprayed....	543	0	100 per cent.	0 per cent.
" " " sprayed.. ..	5	560	1 " "	99 " "
Fameuse Apples not sprayed..	1722	916	65 per cent.	35 per cent.
" " sprayed............	278	2549	10 " "	90 " "
Yellow Bellflower Apples, not sprayed	559	248	69 per cent.	31 per cent.
" " " sprayed.....	16	757	2 " "	98 " "
R. I. Greening Apples not sprayed....	90	286	27 per cent.	73 per cent.
" " " sprayed.......	1	470	0.5 " "	99.5 " "
Winter Strawberry Apples not sprayed	739	174	80 per cent.	20 per cent.
" " " sprayed...	14	1373	1 " "	99 " "

The results from spraying this orchard may be briefly summarized as follows:

Flemish Beauty Pears: The amount of scabby fruit was reduced from 100 *per cent on the unsprayed trees to less than* 1 *per cent on the sprayed tree ; the amount of No.* 1 *fruit was increased from* 55 *per cent on the unsprayed tree to* 99 *per cent on the sprayed tree ; the market value of the crop was increased in the ratio of from* 46 *to* 100, *or a gain of* 117 *per cent.*

Fameuse Apples : The amount of scabby fruit was reduced from 65 *per cent on the unsprayed tree to* 10 *per cent on the sprayed tree ; the amount of No.* 1 *fruit was increased from* 43 *per cent on the unsprayed tree to* 60 *per cent on the sprayed tree ; the value of the crop increased in the ratio of from* 58 *to* 100 *or* 72 *per cent on the lower limbs of the tree, and in the ratio of* 79 *to* 100 *or* 27 *per cent on the entire tree.*

Other varieties subject to scab (Yellow Bellflower, R. I. Greening): The amount of scabby fruit was reduced from an average of about 50 *per cent on the unsprayed trees to about* 4 *per cent on the sprayed trees ; the amount of No.* 1 *fruit increased from about* 55 *per cent on the unsprayed trees to* 80 *per cent on the sprayed ; and the value of the crop increased in the ratio of* 81 *to* 100 *or* 23 *per cent.*

Four applications of the mixture gave as good results as six or even seven.

V.—OBSERVATIONS UPON THE OCCURRENCE OF OAT SMUT IN 1894.

Extensive examinations of oat fields in various parts of the State were made in 1892 and in 1893. The results as published in the reports of those years showed that there was a remarkably small per cent of oat smut in the State during this period. There seemed no occasion for a continuation of the work on so large a scale in 1894, and accordingly only a small number of fields in the vicinity of Burlington were examined. The results of these examinations were as follows :

Samples taken from	Source of the Seed.	Sound Heads.	Smutty Heads.	Per cent. of smut.
Experiment Farm........	Vermont..	293	11	0.4
Experiment Farm.........	Vermont...........	467	11	2.3
Experiment Farm..........	Western...........	384	3	0.8
R. R. Richardson.........	Vermont...........	539	4	0.7
Mary Fletcher Hospital...	Unknown..........	799	40	0.5
Peter O'Clair............	Unknown..........	353	13	3.7
Peter O'Clair............	Unknown.........	350	3	1.0
Geo. Durfee.............	Unknown..........	303	0	0 0
H. H. Goodell...........	Western...........	832	12	1.4

Average per cent of smut in the 9 fields 1.7. The average amount of smut found in 81 samples examined in 1892 was 1.6 per cent. In the 97 samples examined in 1893 an average of only .76 per cent of smut was found. The results obtained from the few samples examined in 1894 thus indicate a slight increase in the amount of smut.

VI.—OBSERVATIONS UPON GRASSES AND WEEDS.

The completed work reported in the previous pages is confined to studies upon plant diseases. In addition, observations and some experiments were begun upon grasses and upon certain weed plants. The grass experiments already begun have in view the selection of some grass or mixture of grasses for use upon overflowed river bottom lands. The only grasses purposely sown at present upon these lands by Vermont farmers are Timothy and Red Top. It seems possible, at least, that some of the native grasses of the State, which are already abundant in favorably situated meadows, may be profitably introduced into more general use. Fowl meadow grass (*Poa serotina*) is the most promising of these, and experiments are under way to test the practicability of its culture.

There are certain weed plants in the State which should be brought more prominently to the attention of the farmers. Among these, the Golden Hawkweed (*Hieracium aurentiacum*) is the most threatening, and experiments testing methods of eradicating it have been begun. The appearance in our State of the similar and closely related Yellow Hawkweed (*Hieracium prœaltum*) may be expected soon as it has been found in northern New York. Another bad weed which is apparently on the increase is Goat's beard (*Tragopogon pratensis*) a species of wild salsify, very similar in appearance to the common "vegetable oyster" of the garden. A still more threatening invader, which is slowly making its way northward through the lower Champlain valley is the Viper's Bugloss or "Blue Devils" (*Echium vulgare*). Two weeds have been causing considerable alarm in the States of the Northern Mississippi valley which have been reported in only a few localities in our State. These are the perennial Sow Thistle (*Sonchus arvensis*) and the Prickly Lettuce (*Lactuca scariola*). The famous Russian thistle (*Salsola kali tragus*) has not yet reached our borders, but it is approaching New England along the lines of the main railroads, both at the north through Canada and the south through New York State.

Vermont has already enough weed plants with which to contend, and anything that can be done to head off these new invaders will be most profitable. Investigations as to their occurrence and means of eradication will therefore be continued, and in due time the results will be published.

VII. SOME STUDIES UPON CARNATION RUST.

Mr. William Stuart, a senior in the Agricultural Course of the University selected the rust* of the carnation as the subject of his graduation thesis. His studies were carried along three lines (1) effect of various chemicals upon germination of the spores, (2) inoculation of healthy carnation plants with the spores, (3) spraying experiments. The following is an abstract of the results as presented in his thesis.

*Uromyces carophyllinus (Schrank,) Schroeter.

(*a*) *Effects of various chemicals upon the germination of the spores.* These tests were made by depending a drop of the fungicidal solution, in which the spores were mixed, from a cover glass which was cemented by vaseline over a moist (Van Tiegham) cell. Considerable variation was found in the germinative power of the uredospores. Quicker and more vigorous germination was always obtained from spores taken from sori borne upon fresh green leaves, that is from leaves whose vitality had not been appreciably lessened by the fungus. In all cases spores taken from sori borne upon the leaves of the plants gave better germination than did those borne upon the stems. The uredospores do not retain their vitality long after reaching maturity. Spores from leaves collected and dried three months before tested, uniformly refused to germinate. Some hopes were entertained that the teleutospores

from these might germinate, but they did not although specimens were kept mounted over two weeks. Fresh uredospores germinated freely in water, good germination being obtained in two or three hours. Considering this as the normal germination, a series of cultures were made in various chemical solutions, to determine if possible the relative effects of these solutions in preventing spore germination, and hence their probable value for fungicidal purposes. About two hundred and fifty separate cultures were made, the solutions used and results obtained being summarized in the following tables:

CHEMICAL USED.	Strength of Solution.	No. of Cultures.	GERMINATION.				Success or Failure as a Fungicide.
			None.	Poor.	Medium	Good.	
Copper Sulphate.	1-100	1	..	..	..	..	Success.
	1-500	2	..	..	..	..	Success.
	1-1000	7	5	..	..	2	Partial Success.
	1-2000	6	2	..	..	4	Failure.
	1-3000	4	2	..	..	2	Failure.
	1-4000	3	2	..	..	1	Unsatisfactory.
	1-5000	3	..	2	..	1	Failure.
	1-10000	1	..	..	..	1	Failure.
(*a*) Bordeaux Mixture.	Standard.	1	1	..	..	..	Success.
(*b*)	⅔ "	2	2	..	..	..	Success.
(*c*)	½ "	2	..	1	1	..	Failure.
(*d*) Ammonical Copper Carbonate.	Del. Sol.	8	3	3	1	1	Failure.
(*e*)	½ "	4	2	..	1	1	Failure.
(*f*)	⅓stronger	6	3	3	..	..	Partial Success.
(*g*) Eau Celeste.	1-100	6	4	2	..	..	Partial Success.
	1-500	12	4	6	1	1	Failure.
	1-1000	10	2	2	2	4	Failure.
Iron Sulphate.	1-100	1	1	..	..	..	Success.
	1-500	1	1	..	..	..	Success.
	1-1000	2	2	..	..	..	Success.
	1-2000	4	4	..	..	..	Success.
	1-3000	3	1	1	..	1	Failure.
	1-4000	2	1	1	..	..	Failure.
	1-5000	1	..	1	..	..	Failure.

(*a*) Six pounds copper sulphate, 4 pounds lime, 22 gallons water.
(*b*) " " " " " 33 gallons water.
(*c*) " " " " " 44 gallons water.
(*d*) Delaware formula, Delaware Bul. No. XXII, 1893; to one volume of 26 Beaume ammonia was added even volume of water. To this was added successive portions of copper carbonate until the solution was saturated. To one volume of the saturated solution, fourteen volumes of water was added.
(*e*) The one-half strength used was made by adding 29 parts of water to one of the solution.
(*f*) The one-third stronger solution was made by diluting the saturated solution with nine parts of water. The latter strength seemed to be about the dividing line between germination and no germination.
(*g*) This solution was highly recommended in the *American Florist* as a sure remedy for rust. Their formula assuming 50 gallons to the barrel, reduced down to the basis of 1 gram to 100 c. c., gave .035 grams sulphate of copper and 26 c. c. ammonia to 100 c. c. water. Good germination was obtained with this strength, and even some germination took place in a solution of 1-100, which was twenty-eight times stronger than that recommended in the *Florist*. That such a fungicide should give beneficial results seem hardly compatible with the results obtained from the cultures made.

CHEMICAL USED.	Strength of Solution.	No. of Cultures.	GERMINATION.				Success or Failure as a Fungicide.
			None.	Poor.	Medium	Good.	
Potassuim Sulphide.	1-100	2	2	..	..	..	Success.
	1-500	6	6	..	..	..	Success.
	1-1000	8	3	4	..	1	Failure.
	1-2000	6	2	2	2	..	Failure.
	1-5000	2	1	..	..	1	Failure.
	1-10000	2	..	1	..	1	Failure.
Potassium Chromate.	1-500	1	1	..	..	..	Success.
	1-1000	6	2	3	..	..	Partial Success.
	1-2000	8	3	3	2	1	Failure.
	1-3000	2	..	..	2	..	Failure.
	1-5000	4	..	..	2	..	Failure.
	1-10000	3	..	1	..	2	Failure.
Potassium Bi-Chromate.	1-500	1	1	..	..	..	Success.
	1-1000	5	1	4	..	..	Partial Success.
	1-2000	7	1	5	1	..	Failure.
	1-3000	3	1	2	..	..	Failure.
	1-5000	3	..	2	..	1	Failure.
	1-10000	1	..	..	..	1	Failure.
Lead Acetate	1-500	4	4	..	..	..	Success.
	1-1000	4	..	2	..	2	Failure.
	1-2000	2	..	..	..	2	Failure.
	1-5000	1	..	..	..	1	Failure.
Corrosive Sublimate.	1-500	2	2	..	..	..	Success.
	1-1000	4	4	..	..	..	Success.
	1-3000	3	..	3	..	..	Partial Success.
	1-5000	8	4	1	..	..	Failure.
	1-10000	6	2	..	2	2	Failure.
Carbolic Acid	1-100	2	2	..	..	..	Success.
	1-200	5	1	1	2	1	Failure.
	1 300	2	..	..	..	1	Failure.
	1-400	1	..	..	1	..	Failure.
	1-500	1	..	..	..	1	Failure.
	1-1000	1	..	..	..	1	Failure.
	1-5000	1	..	..	..	1	Failure.
Salt	1-100	4	2	..	1	1	Failure.
	1-500	3	1	..	1	1	Failure.
	1-1000	3	1	..	2	..	Failure.
	1-2000	2	..	1	..	1	Failure.
	1-5000	2	..	..	..	2	Failure.

(2) *Inoculations of healthy carnation plants with the spores:* A series of inoculations were made under various conditions. Five weeks later microscopic examination of the tissues of the plants in the vicinity of the inoculations detected the presence of the mycelium in several cases. These were all cases in which the epidermis of the plant had here broken by needle puncture. In no case where this was not done was the mycelium found. No sori were found, the time being too short.

(3) *Spraying Experiments:* In order to ascertain whether the chemicals used in the germination tests could be used without injury to the plants two plants were sprayed June 12, with each of the following solutions. The strength of solution used in each case is that which prevented spore germination. The final examinations of the plants made July 29, showed no perceptible injury in any case:

No. I. Potassium Chromate, 1–500.
No. II. Potassium Sulphide, 1–500.
No. III. Potassium Bichromate, 1–500.
No. IV. Potassium Iron Sulphate, 1–500.
No. V. Copper Sulphate, 1–500.
No. VI. Lead Acetate, 1–500.
No. VII. Corrosive Sublimate, 1–500.
No. VIII. Carbolic Acid, 1–100.

NOTICE. The following, written as a footnote to report of the experiments with Bordeaux mixture upon potatoes, was by mistake omitted from its proper place and is inserted here:

The first observations upon the value of Bordeaux mixture in checking insect attacks upon plants were made by Prof. H. Garman of the Kentucky Experiment Station in 1889. These observations are recorded in second Annual Report of the Kentucky Experiment Station, issued in 1892, and in Agricultural Science of March, 1892. These did not come under notice until after the publication of our observations along similar lines made in 1893.

Vt. Rept. 9, 1895 1896

VALUE OF SKIM-MILK AND BUTTER-MILK.

The main purpose for which pigs are kept in this State is as a profitable means of utilizing dairy by-products. It would be a fair and is, indeed, a common method of figuring to subtract the cost of grain from the total receipts, allowing manure to offset care, and calling the remainder the value received for skim and butter milks.

Hitherto we have found this value to be 25 cents and upwards per hundred pounds. No such figure was obtained in this test however, because of low prices and prolonged feeding. Yet even the low amount returned is greater than most dairymen ascribe to it.

3,071 pounds increase in live weight, sold for..................	$128 50
5,597 pounds corn meal, 1,406 pounds of whole corn, 2,091 pounds corn and bran..........	79 00
15,494 quarts skim-milk were worth...............	$49 50

or **15** cents per 100 pounds.

642 pounds increase in live weight, sold for....................	$27 50
1,288 pounds of corn meal, and 617 pounds of corn meal and bran, cost	16 44
2,508 quarts of butter milk were worth..........................	$11 06

or **24** cents per hundred pounds.

It is probable that the relatively high value apparently placed on butter milk is due to the individual excellence of the animals fed upon it, and to the handicap already mentioned in the late initiation of the feeding experiment with Nos. 11–14. Omitting these the value of skim-milk as fed to the remaining eight pigs was **20** cents per hundred.

FERTILIZING VALUE OF FEED.

The foods which were used were rich in plant food, much of which was capable of being saved. Skim-milk and butter milk are worth 11 and 10 cents per hundred, corn meal 30 cents and bran 60 cents per hundred as fertilizers (1895 trade values). The total fertilizing value of the food eaten was $79.04. The food cost $150.99. Its manurial value was, therefore, **52** per cent of its market price as food.

REPORT OF THE BOTANIST.

L. R. JONES.

The results of the investigations of the past year in the botanical department are discussed under the following heads:

I. POTATO BLIGHTS.

1. RELATION OF THE LATE BLIGHT TO THE WEATHER.

It is a matter of common observation that the fungus causing late blight (*Phytophthora infestans*) develops rapidly on potatoes only under certain climatic conditions. These conditions are represented by what is popularly termed "muggy" weather, i. e., high temperature with a saturated atmosphere and frequent showers. Until such conditions prevail the fungus, even if present to a considerable extent in a field, does not cause any serious

blighting of the plants and does not produce spores in such numbers as to lead to much rotting of the tubers. Such adverse conditions for the fungus prevailed here in 1894, for example, when in spite of a badly infested seed from the crop of 1893 no blight and but little rot was observed.

This fact explains why the late blight is confined to so narrow a belt in this country, the present testimony indicating that this potato disease usually causes but little trouble outside of New England, Northern New York and the adjacent portions of Canada, the diseases popularly known as blight or rot of potatoes outside of this region being attributable to some other cause. In order to study more carefully these peculiar climatic conditions which lead to the development of the fungus the following charts were prepared showing for several years past the conditions of rainfall and temperature which have occured during the period in which the disease has appeared and passed its worst stage. The date of the appearance of the blight and the rapidity and extent of its development are also indicated.

The records at hand give the mean daily temperatures and the daily rainfall, but do not show the humidity of the atmosphere. Theoretically, the conditions most favorable for the development of the fungus are a warm, moist atmosphere with precipitation enough to keep the surface of the plant moist. Although no data as to its humidity were at hand the amount of moisture in the atmosphere is directly indicated by the relative rise and fall of the temperature and rainfall curves outlined in the accompanying charts. Thus a copious and long continued rainfall or a slight fall in temperature accompanied by a heavy rain indicates an atmosphere heavily charged with moisture; accordingly we may expect to find that potatoes were attacked by the blight when the above conditions, i. e., abundant rain and comparatively high temperature are indicated. An examination of the charts, and of the records showing the date of the occurrence of the disease from year to year, proves this to be the case.

1891. The temperature was low and rainfall slight the last of July and first of August. August 10th, however, the weather became very warm and on the 12th and 14th was followed by a fall in temperature and copious rains, and this followed by another rise in temperature and more rains about the 21st. The conditions favoring the blight began thus about the 12th. The blight was first observed the 16th or 17th. When it is remembered that such a fungus requires several days in which to get under way before noticeable injury appears, it is seen that the records place the occurrence of the blight at the time when it might be expected.

1892. Late July and early August were very warm but there was little rainfall and a comparatively dry atmosphere. From August 6th to 12th almost ideal conditions prevail for the blight and reference to the records shows that it in reality appeared August 10th, and progressed with unpre-

Charts showing relations of rainfall and temperature to the appearance of the fungus causing the late blight, *Phytophthora infestans D. By.* The time and rapidity of development of the disease is shown by the contour of the shaded portions.

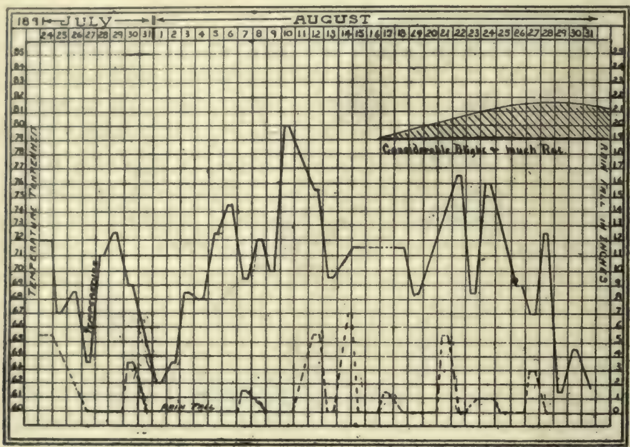


CHART FOR THE SEASON OF 1891.

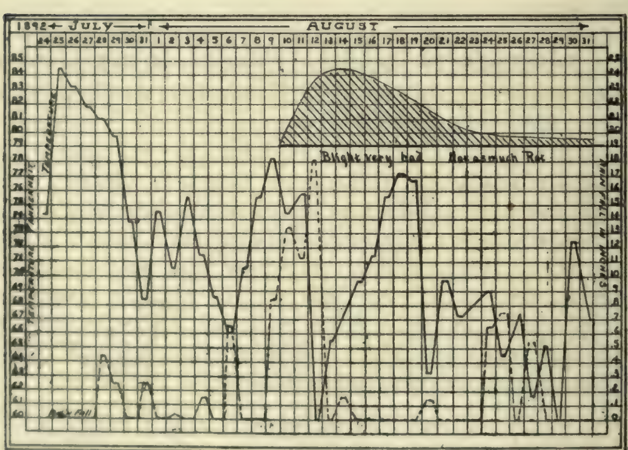


CHART FOR THE SEASON OF 1892.

Charts showing relations of rainfall and temperature to the appearance of the fungus causing the late blight, *Phytophthora infestans*.

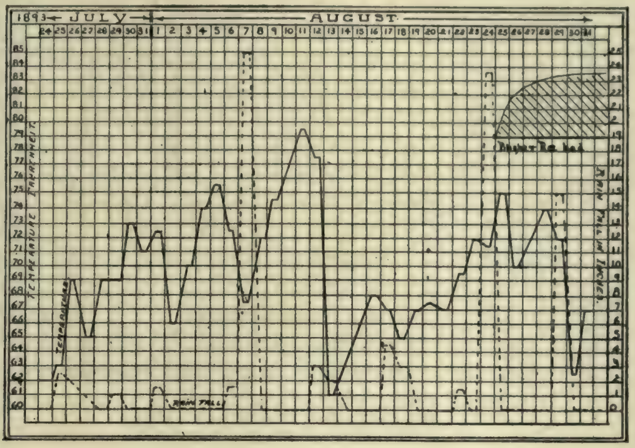


CHART FOR THE SEASON OF 1893.

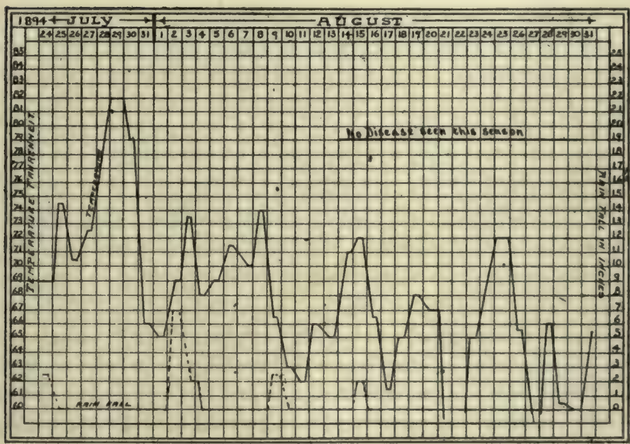


CHART FOR THE SEASON OF 1894.

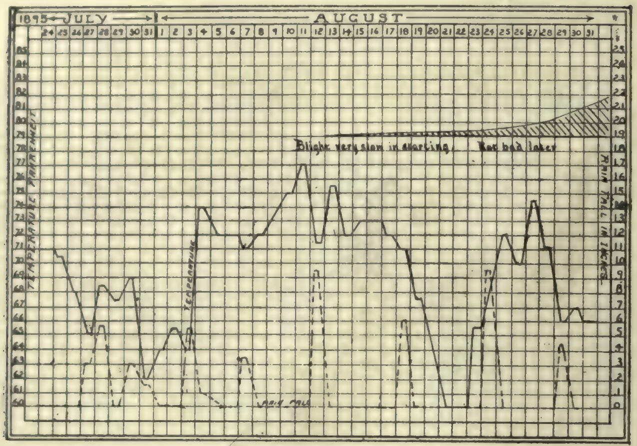


CHART FOR THE SEASON OF 1895.

cedented rapidity so that almost every potato plant was destroyed by it before August 20th.

1893. There were conditions favorable for the disease from August 7th to 13th, but no blight was observed at that time. However, early potatoes whose tops were dead at the time the blight was first noticed, August 25, showed quite a percentage of rotten tubers; thus it is probable that the blight was present on these early potatoes at the period indicated by the charts as favorable, but escaped observation. Another bit of evidence pointing this way is the fact that a piece of late potatoes adjacent to these early ones was attacked by the blight fully a week earlier than was another piece in an isolated locality, but planted with the same strain of seed.

The later conditions favoring the blight began about August 22d, and the disease is recorded as under full headway by the 25th, and as continuing into September with unusually destructive results.

1894. July was warm but dry, and August was cool and dry to an extent unknown in the memory of "the oldest inhabitant." These conditions proved so unfavorable to the fungus that no blight was seen upon the leaves during this season. A small amount of dry rot was found in the tubers upon digging them, thus showing that a very little of the fungus did occur.

1895. Favorable conditions for the blight were present from the 7th to the 20th of August. Very little was seen, however, until the last of the month. This tardiness, in the development of the disease, must be accounted for by the fact that there was so little chance for the fungus to grow

during the preceding summer that a remarkably small number of diseased tubers were present in the "seed" planted in 1895. The original centers of infection in the fields were therefore few and scattered. It was nevertheless true that this slow development of the fungus on the leaves was followed by a very bad rotting of the tubers.

This last condition is however not uncommon and is to be explained by the fact that during the slow progress of the disease on the leaves a continuous discharge of spores upon the soil occurs, while in case of the more rapid destruction of the vines there is a correspondingly shorter period of this soil infection and correspondingly less rot of the tubers results.

The question is frequently raised whether there is not danger of the disease being introduced to the portions of the country where it does not now prevail by importation of seed tubers from sections where the disease is common. The experience of 1894 already referred to effectually denies any such probability. The seed tubers grown by us in 1893 were badly infected with rot, and we should undoubtedly have suffered seriously in 1894 if conditions had favored. With unfavorable climatic conditions the disease was completely checked and had similar conditions prevailed in 1895, we feel confident that the fungus would have been practically exterminated in this vicinity. Unquestionably such a fate has overtaken it in all the dryer states of the south and west, whenever it has been introduced in infected seed, and such will continue to be the case wherever the climatic conditions are adverse to the fungus.

2. SELECTION OF "SEED" AS A PREVENTIVE OF LATE BLIGHT.

As opposed to the closing statement of the preceding article, however, we wish to state that the experience of 1894-5 teaches emphatically that where the climatic conditions are favorable to the blight as they are in Vermont, a great deal of the loss from the disease can be prevented by proper selection of the seed for planting. Our argument is based on the following experience: Early in August, 1895, the warm rainy weather which usually leads to the blight set in and persisted with more or less continuity throughout the month. Yet there was no general outbreak of the late blight.

How is this to be explained? As stated in previous accounts of this disease, the fungus causing it lives over winter in diseased potato tubers, and so far as known, only in this way. Owing to the continued drought of 1894, there was during that season but little opportunity for the development of the late blight and the accompanying rot. Consequently the seed potatoes raised in this vicinity in 1894, and planted in 1895, were almost entirely free from this disease.

Had they been absolutely so there would have been no appearance of the blight in 1895. But careful examination of our own crop in the autumn of 1894 showed that there was an occasional case of "dry rot" among the

tubers. This indicated the presence of enough of the disease to insure its survival through the winter in many of the apparently healthy "seed" potatoes. There were, however, so few diseased tubers planted as compared with ordinary years, and these original centers of infection were consequently so much fewer in the fields, that the blight was fully two weeks later in getting under headway than is ordinarily the case under the same climatic conditions. One early piece of potatoes upon which we were experimenting blighted quite badly in August. On all the other plots there was no destructive spread of the late blight before September 1st. Once well started, however, the disease spread persistently through September, and caused a large amount of rot in the later potatoes, while the early ones were practically free from the disease.

The experience of this year teaches a most important lesson, which if generally heeded would save Vermont potato growers from the loss of thousands of dollars annually, viz.: that *seed potatoes should be taken from a field which did not suffer from the late blight and the rot*. In the vicinity of Burlington the earliest planted potatoes, especially if on a light, dry, sandy soil, usually escape the late blight. Similar conditions exist throughout the State, and seed potatoes should be selected from such a source. If this were to become the *general practice* the saving would be incalculable. Unfortunately the careful individual must often suffer because of the continued propagation of contagious diseases, whether of plants or animals, by ignorant or slothful neighbors. One man alone cannot suppress an epidemic. Concerted action is necessary for the best results. There was, however, such a marked difference last year in the date of the appearance of the late blight in this vicinity upon plots of potatoes separated by only a short distance, that we believe that with potato fields more widely separated, as they are on ordinary farms, each man can do much by use of healthy seed to save his own crop in spite of the bad practice of less intelligent neighbors. Careful choice of seed, and in many cases the growing of a small piece of potatoes for seed purposes, is therefore strongly recommended as a preventive measure against the late blight and rot.

It is vain, however, to hope that any such precautionary measures as selection of seed will do more than delay for a time the outbreak of the late blight upon the average Vermont potato field when the weather is favorable.

3. VARIOUS FORMS OF POTATO "BLIGHT" AND THEIR CAUSES.

Owing to the complications of the characteristic "early blight" of the potato with injuries due to drought, insect attacks and arsenical poisoning, a careful study of the various causes leading to the premature death of potato leaves and of the fungus growths found upon dead or dying leaves was undertaken during the summer of 1895. The diseased conditions pre-

vailing in the vicinity of Burlington were first studied carefully, and, later, the studies were extended to various localities in this and other states.

The details of these investigations were largely entrusted to Mr. C. C. Tracy, who was employed as botanical assistant during the summer and later continued the studies as preparation for his graduation thesis in the Agricultural Department of the University.

Much credit is due Mr. Tracy for the patient and thorough manner in which these investigations were pursued, and it is with deep sorrow that we add that the final completion of these studies was interrupted by his sickness and death.

Mr. A. J. Grout has been employed to assist in a portion of the work of 1896, and in so far as his laboratory investigations are a continuation of those begun in 1895, the results are included in this report.

The work has consisted of extended field observations coupled with microscopic examinations of diseased leaves to determine the nature of the injuries and the presence of fungus or other injurious agencies; of applications of Paris green under varying conditions and of various strengths, noting injurious effects; and especially of the securing of pure cultures* of such fungi as were found commonly associated with the leaf injuries and the inoculation of potato leaves with such of these as were suspected of having any causal relation to the injuries.

The result of these studies was to clearly distinguish at least three well marked and serious disorders which were passing current under the popular name of "early blight." These are:

1. The typical *Early Blight* or "Leaf Spot" disease.
2. *Arsenical Poisoning* from Paris green, etc.
3. *Tip Burn* from drought, etc.

The general appearance of leaves showing injury from each of these three causes is shown in Figures 1, 2, 3, and 4.

In order to present the practical conclusions from these studies to potato growers Bulletin 49 has been prepared (published December, 1895), in which is described the general cause and appearance of each of these disorders together with suggestions for their prevention.

As supplementary to this bulletin we here give a more detailed account of the observations and studies upon which the more important conclusions there presented were based.

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* In making a careful study of any fungus it is advantageous to secure it in "pure culture"; that is to get a growth of it started in a closed dish upon some artificial food substance and free from mixture with other fungus growths and from bacteria. The structure and development of the fungus can then be more carefully studied and by means of inoculations from such cultures upon healthy plants the disease producing ability of the fungus can be critically tested.

In these studies various culture media were tried, but most of the cultures were made either upon "potato leaf agar" a decoction of potato leaves stiffened by the addition of from one to two per cent. of agar, or upon "prune agar" a decoction of prunes similarly stiffened.

Figure 1. EARLY BLIGHT OF THE POTATO (Leaf-Spot Disease) in its *early stages* on a young leaf. Caused by the fungus *Macrosporium Solani. E. & M.* Compare with Figure 2.

Figure 2. EARLY BLIGHT OF THE POTATO (Leaf-Spot Disease) in its *later stages* on an old leaf. The rings or "target board" markings very characteristic of such old spots are here shown more distinctly than they appear on the actual leaf. Compare with Figure 1.

Figure 3. Arsenical Poisoning of the Potato Leaf by improper use of Paris green. The dead spots in the leaf are black or brown. Note that they all originate at flea-beetle punctures or other injuries. Compare with Figure 2 since these two troubles resemble each other so closely as to be easily confused.

Figure 4. Tip Burn of the Potato Leaf, due to hot, dry weather combined with any other agencies which weaken the plant. Often occurring with Early Blight and commonly confused with it.

POTATO DISEASES AS THEY OCCURRED IN 1895.

Scarcely a trace of *Phytopthora infestans* (the fungus of the late blight and rot) was seen before September first, ***upon our experimental plots.*** From the middle of July until this date there was abundant opportunity to study the several forms of disorder classed popularly under the name of "Early Blight." The first cause leading to serious killing of the leaves was Paris green. During June and early July nearly every field examined showed abundant evidence of overdoses of this poison. The appearance of the leaves is shown in Fig. 3. In addition to the account given in Bulletin 49 (p. 97) we will only add that experiments with Paris green mixtures applied to leaves of potato plants grown in the green-house this winter show that plants of the same variety grown in the warm, moist atmosphere of the house are much more susceptible to injury than are those grown in the field and that the injurious action is more severe where the epidermis of the leaf is freshly broken. This emphasizes the need for more caution in the use of the poison since the fact that the poison applied in a certain way one year does not injure the plants will not guarantee equal safety from its use under different conditions or with another variety of potato. As stated in the bulletin referred to, the poison should be applied with more care. The earlier applications are best diluted with gypsum or similar powder and applied dry; later it can be used with perfect safety in the Bordeaux mixture. If water is used as a carrier for the poison, an amount of freshly slacked lime, at least equal to the amount of poison used, should be added to the water to neutralize the soluble arsenic.

The tissues killed by Paris green remained practically free from fungus growths so far as observed, but from the middle of July till the killing of the last plants by frost, there was an abundance of dying potato leaves upon our fields, the cause of whose death was neither Paris green nor *Phytophthora infestans*. As stated on a previous page and described in Bulletin 49, two forms of malady were constantly found—one the "Early Blight," properly speaking, the other "Tip-burn." See Figures 2 and 4. The two were about equally in evidence upon the Experiment Station field. In some other fields seen one or the other of these maladies was alone responsible for most of the loss. The gross appearance and favoring conditions and remedies for these disorders have been described in Bulletin 49. It only remains to discuss in detail the laboratory studies pursued.

Three species of fungi were very commonly found upon these diseased potato leaves. They were *Macrosporium Solani E. & M.*, a species of *Cladosporium*, (apparently *C. herbarum*) and a species of *Alternaria*. The *Cladosporium* was clearly a saprophyte, invading only dead tissues and no extended study of it was undertaken.

The marked resemblence of the spores of the other two species made their discrimination very difficult until they were grown in pure cultures.

Studies of the *Alternaria* in such cultures showed it to be a species unable to gain an entrance into living potato leaves, although it is still doubtful if it may not in some cases aggravate or increase the diseased conditions after having gained entrance, and its wide-spread occurence in connection with Tip-burn make it liable to constant confusion with the *Macrosporium* in laboratory investigations. We have felt justified, therefore, in continuing detailed studies upon it even after we were convinced of its saprophytic nature.

For convenience we will give first the results of the studies upon the true early blight fungus (*Macrosporium Solani*) and later the discussion of this *Alternaria*.

Studies Upon Macrosporium Solani,* E. & M.

This fungus was first described by Ellis in American Naturalist in 1882** as occurring on potato leaves. Its relation to the now familiar early blight of potatoes was recorded in 1891 and 1892 by various observers in this country and Australia.†

The opinion was generally expressed or implied by these observers that the fungus was the cause of the disease, although its association with insect injuries or an otherwise weakened condition of the leaf was constantly noted.

Chester stated in 1891 that he made successful infections of the leaves of tomato plants with the fungus ‡ and Galloway || states that spores sown on healthy potato leaves produce the characteristic spots in eight or ten days.

Dr. Sturgis after reviewing this evidence in 1894§ considers that Chester's inoculations from the manner in which they were made were inconclusive, and that evidence is still lacking to prove that the fungus is the direct and only cause of the disease. He concludes that "it seems possible that the early blight of potatoes may be due to the physiological effects of extreme heat and dryness acting upon leaf tissues at a distance from the roots and already injured by predatory insects, and that tissues so injured are liable to the attacks of certain fungi, which may enhance the injury." After further discussion of Dr. Sorauer's classification of so-called parasitic fungi into

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* Observations recorded later in this Report, show this species also to be an Alternaria, not a Macrosporium as heretofore supposed.

** Am. Nat. Dec. 1882, p. 1003.

† Humphrey in Rep. Mass. Agr. Exp. Sta. 1891, p. 226.

Chester in Rep. Del. Agr. Exp. Sta., 1891, p. 58.

Galloway in correspondence and in Garden and Field, Adelaide, Australia, for June, 1891. See also notes and discussion in Rep. Vt. Exp. Sta., 1891, p. 131 and 1892, p. 66.

‡ Loc. Cit. p. 59.

|| Agricultural Science, Vol. VII., p. 377.

§ Rep. Conn. Agr. Exp. Sta., 1894, p. 132.

three classes, absolute parasites attacking uninjured healthy organs, partial parasites attacking uninjured but unhealthy organs and wound parasites attacking injured organs at the point of injury, he suggests that the early blight fungus may be included "in the second or possibly the third class instead of in the first class as heretofore."

Our own previous observations had led us to consider the fungus an active disease inducing agent, but we had felt the need of more careful study along the lines suggested by Dr. Sturgis, and undertook in 1895 to obtain answers to the following questions:

1. With what forms of potato leaf injuries is the fungus *Macrosporium Solani* associated?

2. Is it possible to produce diseased spots by inoculating healthy living potato leaves growing under normal conditions with spores taken from a pure culture of this fungus?

In obtaining evidence regarding the first point hundreds of potato leaves were collected and examined from our own fields, a large amount of material collected at Burlington and other points in Vermont during previous years was re-examined, and finally examination was made of a considerable material sent from the various experiment stations of the Northern and Eastern States. The results were conclusive. In all cases where the characteristic "early blight" spots occurred in the interior of the leaves, the diseased tissues were found to be invaded by this fungus, and usually by no other in the earlier stages of the diseases. In the earlier part of the season (in July and early August) many of these spots plainly centred about flea-beetle punctures or similar injuries, allowing of no doubt that the fungus gained entrance to the interior tissues at such points of injury, but more spots could be found on nearly all diseased leaves which showed no such relation to insect or other injuries. The leaves which began to spot earliest in the season were the lower, and hence older and more shaded leaves of the plants. There was also an evident preference of the fungus for the weaker leaves, and for the weaker portions of the leaves, i. e., tips and marginal areas. As the season advanced the disease increased and the spots were no longer confined to the lower or older leaves and in a great majority of cases showed no relation to insect injuries, the small green leaves at the summit of the plant, becoming peppered with spots almost as soon as expanded. These facts are in accord with our observations in 1892, that "insect punctures or other injuries to the leaf offer a favorable starting point for this fungus," and that "this disease does little damage [in Vermont] until after the plants blossom and pass their stage of greatest vigor."* The fungus is, however, decidedly more than a wound parasite attacking unmutilated portions of living leaves. As it occurs in Vermont it is well described by a term employed by Dr. Sorauer of Berlin, in a recent letter, as one of the

*Rep. Vt. Agr. Exp. Sta., 1892, p. 67.

class of "Schwache-parasiten," a German expression hard to translate into English but for which we suggest the term "weakling parasites," i. e., parasites upon weakly organisms.

The economic importance of the fungus is scarcely lessened by this fact, however, since the latter part of the life of the potato plant is of the greatest practical importance to the cultivator, and when it is lessened by even a week the loss is serious.*

In order to secure answers to the second question proposed, viz: as to the ability of the fungus to gain an entrance into living potato leaves, pure cultures were started from single spores of the *Macrosporium*. Such cultures produce spores very sparingly in their earlier stages, but later under favorable conditions often sporulate freely.

When the surface of such a spore-bearing culture is rinsed with water an abundance of free spores is easily obtained in the water, and at a favorable temperature these begin to germinate almost immediately. (See Figure 1, of Plate 1.) Inoculations were usually made in our investigations by applying some water thus charged with fresh spores upon the potato leaf by means of a recently sterilized camel's hair brush. Inoculations were repeatedly secured in this way, in which diseased spots infested with the fungus appeared within three to five days after the application of the spores upon leaves which were vigorous at the beginning of the experiment.† In most of this work we were obliged to use potato plants grown in the greenhouse and they were confined for a short time after the inoculation under a bell jar. It is true that a plant thus grown in the winter in the moist atmosphere of the greenhouse is probably less able to resist the invasion of fungi than is a similar plant grown out of doors during the summer months, yet the conditions are not altogether unlike those existing out of doors during a period of rainy weather. While the results of these inoculations made by Mr. Tracy during the winter months had, therefore, answered the second question in a fairly satisfactory manner, it seemed desirable, for the reasons given, to repeat the work with plants grown out of doors. This has been done with the assistance of Mr. Grout during the present summer (1896) and owing to the delay in the publication of this report we are able to add that

*See discussion of the "Time and Rate of Growth of Potato Tubers," Vt. Bul. 40, p. 26.

†The most serious obstacle in the process of securing inoculations lay in the difficulty of preventing the spores strewn upon the surfaces of the leaves from drying. This was overcome in some of the experiments by placing dishes of steaming water under the bell jar while covering the outside of the jar with a towel wet with cold water, in others a flask of water was kept gently boiling, and the steam thus generated was conducted to the interior of the jar through a glass tube. A very convenient scheme used by Mr. Grout was to draw to a fine hair like point a glass tube of rather large bore. By filling this tube with water and suspending it at an angle with the minute orifice of the capillary end over the leaf a slow dripping of water resulted which was regulated at pleasure so as to replace the water upon the inoculated leaf as rapidly as it evaporated.

these infections have been fully as successful as those obtained in the greenhouse. The details of a single experiment will suffice.

In order to force the growth faster and handle the plants more conveniently potatoes were grown in pots, starting them in the greenhouse and later setting the pots in the soil out of doors. The plant in question was about one month old, and in full vigor. The spores were applied in water with a camel's hair brush, as already described, to one of the younger leaves (including its several leaflets) situated near the top of the plant on the northeast side. This was done at 7 o'clock P. M. There was a fairly copious dew that night. As the air was warm and dry the next morning, a large bell jar was placed over the plant and remained there until evening to prevent the thorough drying of the surface of the leaves. Water was dropped from a pipette upon the inoculated leaf at intervals during this day and the next also.

On the sixth day after the application of the spores small black spots were visible on the leaflets. These gradually increased in size and numbers, having in all ways the characteristic appearance of the typical early blight spots caused by the *Macrosporium*, including the "target board markings."

On the ninth day one of the smaller leaflets, which had a well developed spot, was removed and examined. Upon the upper surface of the leaf about the middle of the spot two large *Macrosporium* spores were found, which had germinated freely and several of the germ tubes were traced into the leaf tissues. Moreover, the dead tissue was thoroughly permeated with a fungus mycelium agreeing in all its characters with the mycelium of the *Macrosporium*. A small portion of the tissue from the diseased spot was examined to determine that there were no spores upon its surface and then placed in a culture dish of agar. A luxuriant growth of mycelium soon began to radiate from it, which proved to be *Macrosporium Solani*. Another leaflet was removed on the fourteenth day after the inoculation. Examination of this leaf showed the presence of sporophores bearing spores of the *Macrosporium* protruding from the under surface of the leaf as well as the upper, thus completing a chain of evidence which must satisfy any existing doubts as to the parasitic habit of this fungus.

Attention is further directed to Plate 1, which shows the vigorous germination of the *Macrosporium* spores and the mode of entrance of the germ tubes into the leaf tissues, both through the breathing pores and by direct penetration of the outer walls of the epidermal cells. These drawings were made from a potato leaf inoculated three days previously. Once within the leaf the fungus apparently finds little difficulty in making its way through and between the cell walls in all directions until the tissue is thoroughly permeated by it. The production of spores is usually delayed until the death of the host tissues and is rarely very abundant even then. The spores are produced on sporophores which either push out through the

breathing pores or break directly through the outer walls of the epidermal cells, being found in greatest numbers on the upper surface.

Many spots infested by the fungus bear few or no spores, however, and rarely are many found. This paucity of spores is somewhat puzzling in view of the very vigorous development of the mycelium. It is not at all probable, however, that the spore production ceases with the death of the leaf tissues. This event appears rather to mark its active beginning. The most abundant sporulation is always found on the dead tissues of the older spots. Moreover, this mycelium retains its life for a considerable period of time, certainly for a year or more, as shown by placing in culture media bits of old potato leaves infested with the fungus when a vigorous growth of the mycelium has followed. Similar bits of mycelium from culture dishes, eight months old, dry and hard, when placed in fresh culture dishes, resumed growth at once. It is quite probable, therefore, that the mycelium passes the winter in a resting condition in the dead tissues of potato plants and produces spores again the following season. The spores likewise retain their vitality for an indefinite period. Those a year old germinate quite vigorously, although we have not as yet succeeded in inducing those two years old to grow. There seems little need then by the fungus of any special resting stage or other form of spore in order to successfully propogate itself, nor have we seen indications of any such condition either on potato leaves or in culture dishes.*

It is a well known law of plants that excessive nutrition retards the reproductive processes. This is the probable explanation of the fact already noted that the fungus rarely produces spores until it has fully sapped the food supply of its host plant. The same tendency was constantly shown in the cultures dishes. No matter how large the dish there was but slight spore production until the surface of the dish was covered. Interesting exceptions which served to prove the rule occured when the mycelium of the fungus came into contact with a chance colony of bacteria in the culture medium, in which case spore production in this vicinity very commonly ensued.

Even more interesting and of some practical utility in our study was the fact that where the spores were thickly sown in the culture dish so that the colonies resulting from the germination of the spores at once began to come into contact with each other their vegetative growth was promptly checked and spore formation ensued. The peculiar colonies shown in Plate II were examples selected from hundreds of similar colonies so produced in the same dish within three days after starting such a crowded culture.

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* It is of some botanical interest to note that cultures of the so-called *Macrosporium Sarcinula*, *Berk. var parasitibum*, *Thum.*, growing in similar cultures along side the cultures of *M. Solani* formed their characteristic *Pleospora* perithecia within a short time while *M. Solani* showed no signs of any variations in its vegetative or reproductive characters.

Ordinarily the mycelium growing in the culture dish forms a thick felted mass filling the upper strata of the culture medium and rising for a twelfth of an inch more or less above it. This pushes out radiating threads in all directions, the rapidity of growth varying with the temperature, from 1-16 to 1-4 of an inch daily in the colonies studied. A curious phenomenon common to many fungi grown thus in culture dishes is beautifully shown by this *Macrosporium*, viz: the formation of concentric rings* as growth continues, darker and lighter rings occuring alternately as shown in Plate III. Mr. Grout, as a result of his studies, is of the opinion that this is a simple result of the periodicity of growth of the fungus, the light ring representing the more rapid growth which ordinarily occurs during the warmer period of the day and the dark ring resulting from the arresting of the growth at night time. The number of rings in the culture dish thus corresponds to the number of successive days and nights of growth unless some unusually favorable or unfavorable conditions have disturbed the normal alternation of temperatures.

SOME OBSERVATIONS UPON A SPECIES OF ALTERNARIA.

Along with the *Macrosporium* on many of the older leaves and especially on those suffering from "Tip-burn," two other species of fungi, a *Cladosporium* and an *Alternaria*, were often very abundant. The *Cladosporium* was so clearly a saprophyte and in no way connected with the blighting of the leaves that but little attention was paid to it. The spores of the *Alternaria*, however, so closely resembled the *Macrosporium*, and the two were so frequently found associated on the same leaf, that it was made the subject of very careful and extended study. So close was this resemblance that when first seen the question arose whether the two might not be simply different stages of the same fungus. Further study, however, removed all doubt on this point, as the two behave differently when grown side by side on the same culture medium and under exactly the same conditions.

Pure cultures of the two have been carried through many generations during several months of time and each remains distinctly true to the type of

* The formation of the characteristic "target board" rings in the potato leaf spots is quite a different phenomenon and, as shown in the Figure 3, such rings are produced by Paris green or indeed will doubtless result from any cause leading to the slow death of the leaf tissues if such death proceeds gradually outward from a central point. It is to be explained in our judgment as resulting from the more complete collapse and consequently rapid contraction of the interior cells or mesophyll of the leaf as compared with the outer epidermal cells. The gradual contraction of the mesophyll toward the common center as it dries throws the overlying epidermis into the characteristic ridges. Similar concentric ridges occur in the case of fungus or other injuries to many of our common plants, e. g., they are very common on dandelion leaves. On the other hand the fact was noted that the usual ridges were not formed in the case of Macrosporium spots upon potato leaves growing in the moist atmosphere of the greenhouse. This shows that they have no necessary relation to the invasions of the fungus.

the original spores from which it sprang. Moreover, applications of the *Alternaria* spores upon potato leaves made at the same time and under the same conditions as those of the *Macrosporium* failed in all cases to lead to successful inoculations. Although there has been no difficulty in inducing it to grow upon dead areas of living potato leaves it has in no case seemed to lead to the enlargement of such areas, apparently being unable to invade the adjacent living tissue. We are led to conclude, therefore, that this *Alternaria* is a saprophyte and to doubt that it plays even a minor part in the destruction of the living tissues of potato leaves.*

The very close resemblance of the single spores of this *Alternaria* to those of the *Macrosporium* and its very common occurrence upon the dead portions of leaves suffering from tip-burn has undoubtedly been in part responsible for the confusion of the true early blight with tip-burn. We therefore figure it in comparison with the *Macrosporium* in Plates I and II

MACROSPORIUM SOLANI E. AND M. AN ALTERNARIA.

The distinction between the genus *Macrosporium* and the genus *Alternaria* is generally recognized as an arbitrary and very unstable one, consisting merely in the manner in which the spores are borne, the *Macrosporiums* producing their spores singly, the *Alternarias* producing theirs in chains. As the two genera are so similar in other respects the presumption is that many of the species now classed as *Macrosporium* will upon further study prove to produce spores in chains.

The question has naturally been raised by various investigators whether *Macrosporium Solani* did not at some times produce its spores in chains after the type of the *Alternarias*.

In a letter received from Mr. K. Sengoka, a Japanese investigator of the Imperial College of Agriculture, Sapporo, in May, 1895, he stated that he had seen such catenulate spore production in a species which appeared to be identical with *Macrosporium Solani, E. & M.*, and that he proposed to publish it accordingly as *Alternaria Solani.* We have expected to learn of such publication, therefore, but have not as yet.

Dr. Paul Sorauer in "Zeitschrift fur Pflanzen Krankheiten," IV Band, 1 Heft, has described under the name *Alternaria Solani, Sorauer* two fungi which he considers identical but which we believe to be distinct. One of these fungi which he describes agrees so closely with *Macrosporium Solani*

* While continuing these studies the present summer (1896), Mr. Grout found this fungus occurring saprophytically upon dead leaves of onions in the garden near the potato plots. Following this, further search proved it to be of very common occurrence on dead leaves or other tissues of a variety of plants, including besides the onion, cabbage, oat, bean, and other garden plants. Finally, upon undertaking some studies of the *Macrosporium* commonly associated with the Black Rot of the tomato (*M. Tomato, Cooke*), it was found that this also is an *Alternaria* and in no way distinguishable from the preceding when grown upon the same culture media.

that Dr. Sorauer considers it the same, the other corresponds essentially with the *Alternaria* described above.

Dr. Sorauer concluded from his observations that the two were but varying stages in the development of one and the same species. In the face of our results we cannot believe this to be true, the only evidence we have seen in favor of such relation being the fact that the two are very frequently found associated on dead potato leaves, and that of course has no real weight. In structure and habits of growth the two are quite different and in no case of pure culture has evidence of mutability been observed. In addition we will only state that from potato leaves kindly sent by Dr. Sorauer, collected in Hungary, both species of fungi have been separated and studied in pure cultures, and that in all respects they appear identical with the two species found on American leaves.

There was found, however, in one of our pure cultures of the *Macrosporium Solani E. & M.* which was sporulating luxuriantly, frequent cases where two spores were clearly joined in pairs as shown in the accompanying figures. The occurence of these spores in such a culture leaves no doubt of their identity; moreover their measurements, as well as other characters,

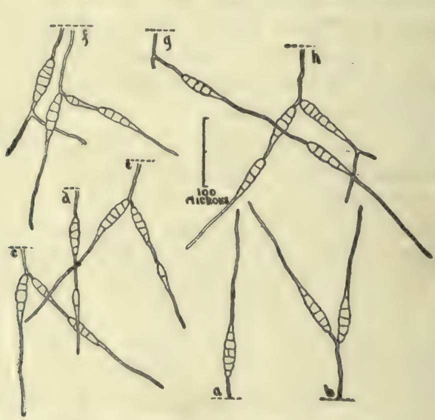


Figure 12. *Macrosporium Solani, E. & M.* grown on Prune-agar, showing spores borne in catenulate pairs after the manner of the *Alternarias*.

correspond with the typical single spore of *Macrosporium Solani* and do not in any way resemble the spores of the *Alternaria* previously described. They, therefore, serve to settle beyond all doubt the fact that *Macrosporium Solani, E. & M.* must hereafter be classed as an *Alternaria* and known as *Alternaria Solani*.

We will leave it for some one more expert in the matter of nomenclature than ourselves to decide upon whose authority the name rests.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Single spore of *Macrosporium Solani, E. & M.*, showing germ tubes protruding from three cells (*a*, etc.) From culture on prune-agar. Magnified 280 diameters.

Fig. 2. Two spores of *M. Solani, E. & M.*, germinating and penetrating surface of living potato leaf. *d*, Normal stoma (breathing pore) of potato leaf; *b*, *b*, similar stomata through which the germ tubes have entered the interior of the leaf; *c*, germ tube penetrating outer wall of an epidermal cell. Spores from culture on prune-agar, examined and drawn five days after placing on potato leaf. Magnified 280 diameters.

Fig. 3. Spores of *Macrosporium Solani, E. & M.* showing peculiar forms. Magnified 140 diameters.

Fig. 4. Spores of the saprophytic *Alternaria* occurring on potato leaves, three mature and three immature. Central one germinating. Magnified 280 diameters.

Fig. 5. Fruiting branch of this *Alternaria* from culture on prune-agar. Magnified 280 diameters.

Fig. 6. Similar branches of this *Alternaria*. Magnified 140 diameters.

PLATE II.

Fig. 7. Young colony of the *Alternaria* from potato leaf grown five days on prune-agar. Many spores were sown in the same dish and as a result early and profuse sporulation followed.

Fig. 8. Young colony of *Macrosporium Solani, E. & M.* from potato leaf grown in same dish with the *Alternaria* of Fig. 7.

4. POTATO LEAF BLIGHTS IN OTHER STATES.

While engaged in these studies during the summer of the past year a visit to the Mississippi valley afforded an opportunity to observe the condition of the potato plants in several localities. A great amount of "blighting" of potato leaves was evident in certain sections which were suffering severely from drought but examinations at several points along the route showed a very general absence of the typical *Macrosporium* trouble. Wishing to carry the studies further, officers of various experiment stations were asked in September to send such material as they could showing the *Macrosporium* or similar "blight" of potato leaves as it had occurred in the vicinity. Owing to the hearty responses received material was secured from

eleven states. This was carefully examined by Mr. C. C. Tracy and following conditions found:

Station from which sent.	Early Blight (*Macrosporium Solani*.)	Tip-Burn.	The Saprophytic *Alternaria*.	Remarks.
Connecticut (Storrs) ...	None	Abundant ...	Abundant...	Macrosporium plenty here in 1894.
Delaware...	Abundant.	" ...	" ...	
Indiana.....	None	"	" ...	
Mass.	"	" ...	Some found.	Macrosporium plenty here in 1894.
Michigan...	Some	"	Abundant...	
Geneva, N Y	Abundant.	"	" ..	Badly eaten by flea beetles.
Ithaca, N.Y.	None	"	" ..	
N. Dakota..	Some......	None..........	None........	....
New Jersey	None ...	Considerable..	Considerable	....
Ohio	Abundant.	" ..	"	....
Rhode Isl'd	" .	Some.	Some........	....
Wisconsin .	None	Abundant....	Abundant...	....

The late (*Phytophthora*) blight was found only in connection with the specimen from Rhode Island.

Since much of this material was collected about September 1st, it would not necessarily represent the conditions which existed earlier in the summer, yet the presumption is that it does so in general. If this is true it indicates that the *Macrosporium* was either less generally prevalent than usual last summer or else that the injury due to it has been much over estimated.

II. BORDEAUX MIXTURE.

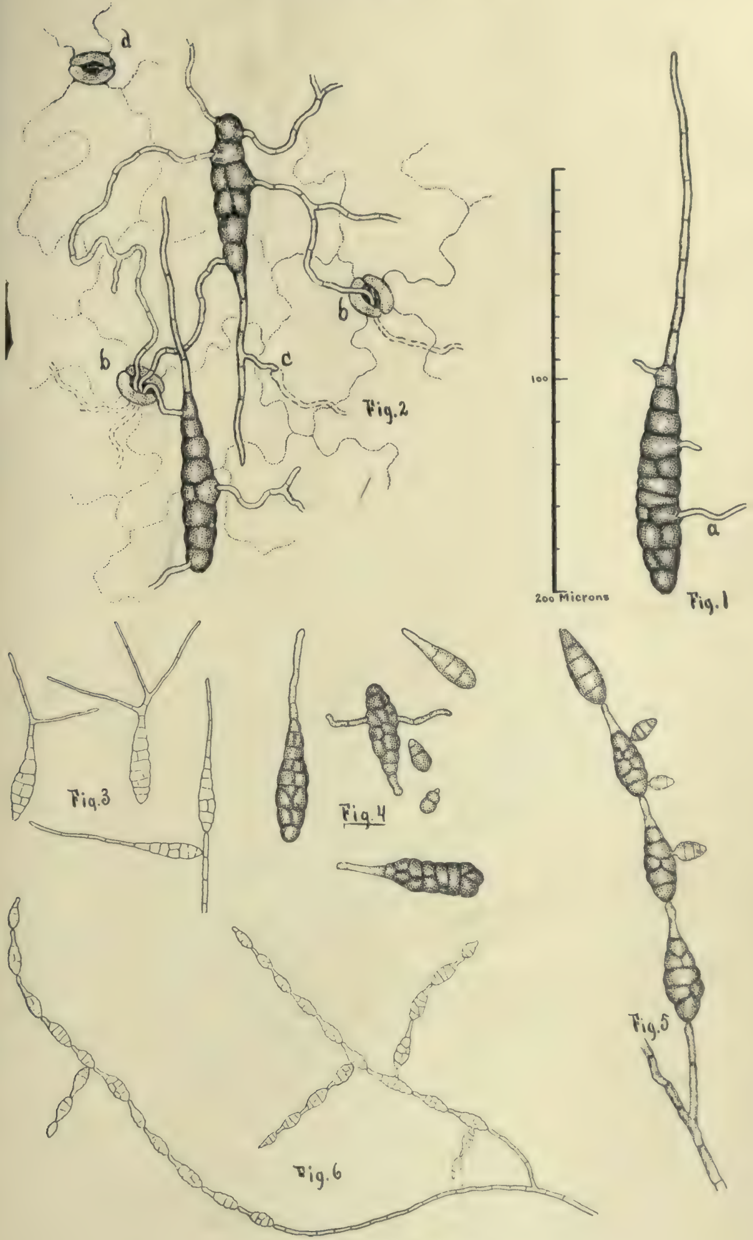
I. METHODS OF PREPARING BORDEAUX MIXTURE*.

Everyone experienced in preparing bordeaux mixture has observed the wide differences in the mixture as made in different ways. These differences are shown by the varying color of the mixture, and by the greater or less speed with which the blue precipitate settles upon standing. The ideal color is a deep blue, with no greenish tint, and the most desirable mixture is the one in which the precipitate settles most slowly. There has been some uncertainity as to the best manner of obtaining these results, however, which uncertainty has been increased since the introduction of the use of the potassium ferro-cyanide test.

*This work was carried out by Mr. W. A. Orton, a student in the agricultural department of the University.

VERMONT AGRICULTURAL EXPERIMENT STATION.

NINTH REPORT, PLATE I.



POTATO LEAF FUNGI.

Fig. 7. The Alternaria from Potato Leaf grown in Prune-agar.

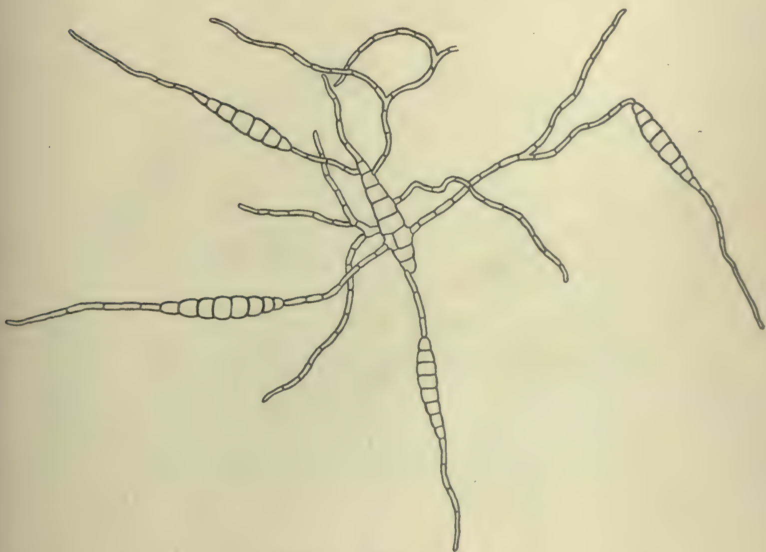


Fig. 8. Macrosporium Solani E. & M. from Potato Leaf grown in Prune-agar.

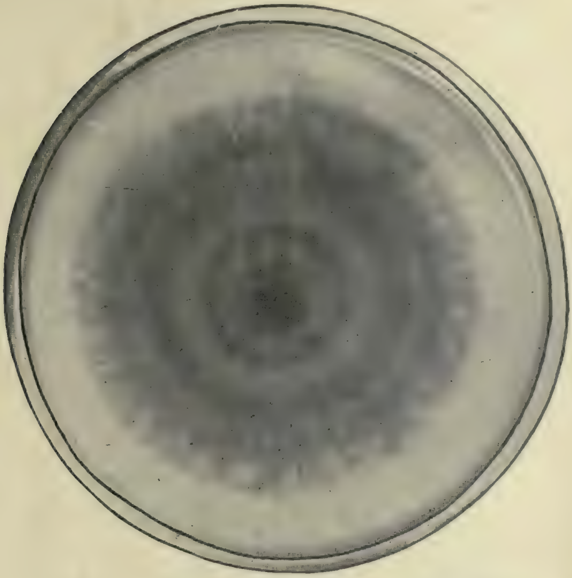


Fig. 9. Culture Dish, showing the Alternaria growing on Prune-agar.

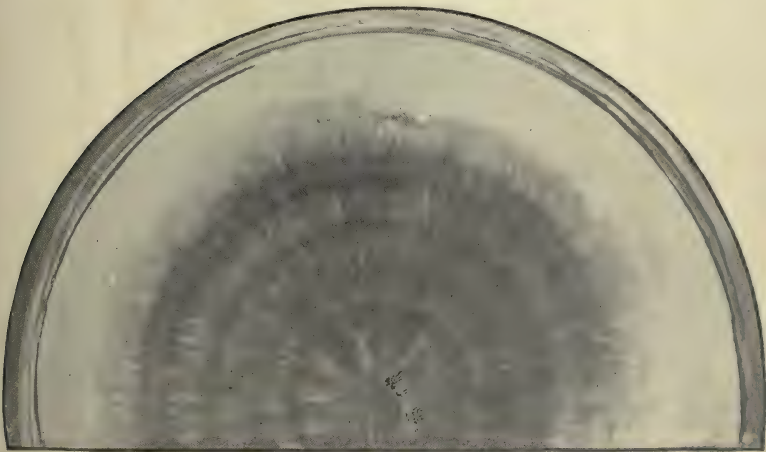
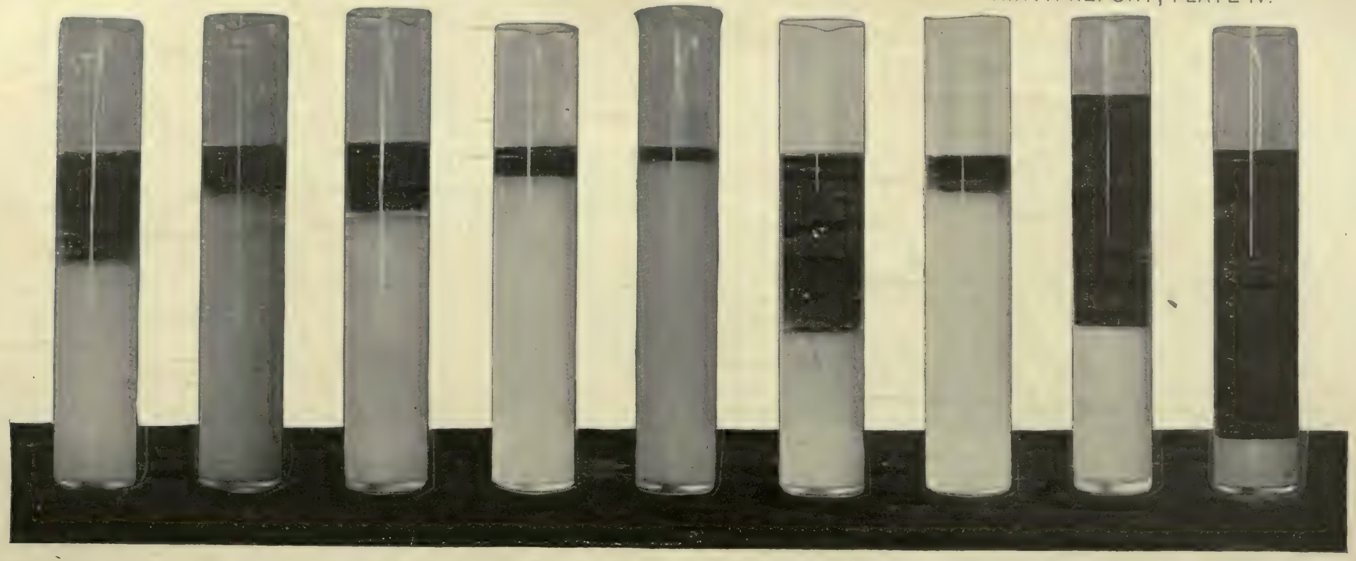


Fig. 10. Culture Dish (one-half), showing Macrosporium Solani E. & M. growing on Prune-agar.



A B C D E F G H I

Figure 11. Jars showing relative rapidity of settling of the precipitate in Bordeaux Mixture made in various ways. Each jar stood one hour after making before photographed. The dark portion in each jar was clear water (colored with ink so as to show distinctly); the lighter portion below was the precipitate.

A. Mixture made by pouring dilute lime into dilute sulphate slowly.
B. Mixture made by pouring dilute sulphate into dilute lime slowly.
C. Mixture made properly (as E.) but using hot lime milk.
D. Mixture made as in E., but less thoroughly stirred.
E. Properly made Bordeaux mixture, *i. e.* from cold dilute solutions, quickly united and thoroughly stirred.
F. Made same as E. but using concentrated solutions.
G. Properly made mixture, one day old.
H. Old or "Stock" Bordeaux mixture, made two weeks before.
I. "Bordeaux Powder" mixed with water.

The recent studies of Mr. Swingle,* most of which have come to our hands since our own work was completed, have done much to clear up the obscurity as to the best methods of preparing the mixture, and so far as our work covers the same ground the results are in accord with those previously obtained by Mr. Swingle.

In order to observe more clearly the character and behavior of the mixtures made in the various ways under trial graduated glass cylinders† were used as vessels to contain them, thus enabling detection of very slight differences in color and also in the rate at which the precipitate settled The character of these vessels is shown in Plate IV.

Unless otherwise stated all mixtures were made with cold solutions in the proportion of one and one-half pounds of copper sulphate and one pound of lime to ten gallons of water.‡

The principal object in view in making the experiments was to learn how well the precipitate would remain in suspension when made in various ways, hence the rapidity of the settling of this precipitate is the chief thing considered in each case.

In order to make the discussion of the results clearer the method found upon trial to produce the best mixture will be described first. It will be seen that this method consists in the *rapid union of cold dilute solutions in such manner as to have at no time any excess of free copper sulphate*,

Such a mixture will be spoken of as "standard" mixture and used as a basis of comparison. The results obtained from other ways of combining the ingredients in comparison with this "standard," will then be discussed in the following order:

Mixtures made with insufficient stirring.

Mixtures made from *concentrated solutions*.

A mixture made with *hot* lime milk.§

A mixture made with "stock" lime milk.

A mixture made by the potassium ferro-cyanide test.

Old mixtures.

"Bordeaux powder" in water.

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*Rural New Yorker, September 28, 1895; U. S. Dept. Agric., Farmer's Bul. No. 38.

†At first cylinders of 500 c. c. capacity were used, later smaller ones (50 c. c.) were substituted as more convenient. The precipitate settles more rapidly in proportion to the total height of liquid in the smaller cylinders. Thus, a mixture that settled five per cent. of the height of the column in the taller, 500 c. c., cylinder settled about eight per cent of the height of the column in the 50 c, c. cylinder.

‡A stock solution of copper sulphate was used, which contained 450 g. to 4000 c. c. of water, or approximately one pound per gallon. Freshly slacked lime was used in most cases, 28 g. lime in 950 c. c. water (about one pound in two gallons). To make 50 c. c. of the mixture there were used 8.5 c. c. of the copper sulphate solution, 10 c. c. of the lime milk and 31.5 c. c. water.

§The lime milk is, properly speaking, a mixture rather than a solution. In order to avoid confusion, however, it is frequently spoken of as a solution, the term mixture in the discussion being applied only to the product of the union of the copper sulphate and lime, viz.: the bordeaux mixture.

HOW THE BEST OR STANDARD BORDEAUX MIXTURE WAS PREPARED.

The process best adapted to field work will be discussed later. (Page 92.) In these laboratory tests the most convenient method and the one followed in this work was to dilute both the copper sulphate solution and the lime milk with one-half of the total amount of water to be used and then pour the diluted lime milk *quickly* into the sulphate solution, following immediately by *thorough mixing*, this mixing being best done by pouring the mixture several times from one vessel into another. Made thus we obtained a mixture of which a four-inch column *after standing one hour settled less than one-sixth of an inch or four per cent.**

Equally good results were obtained when the diluted sulphate solution was quickly poured into the diluted lime milk and the combination immediately and thoroughly stirred.

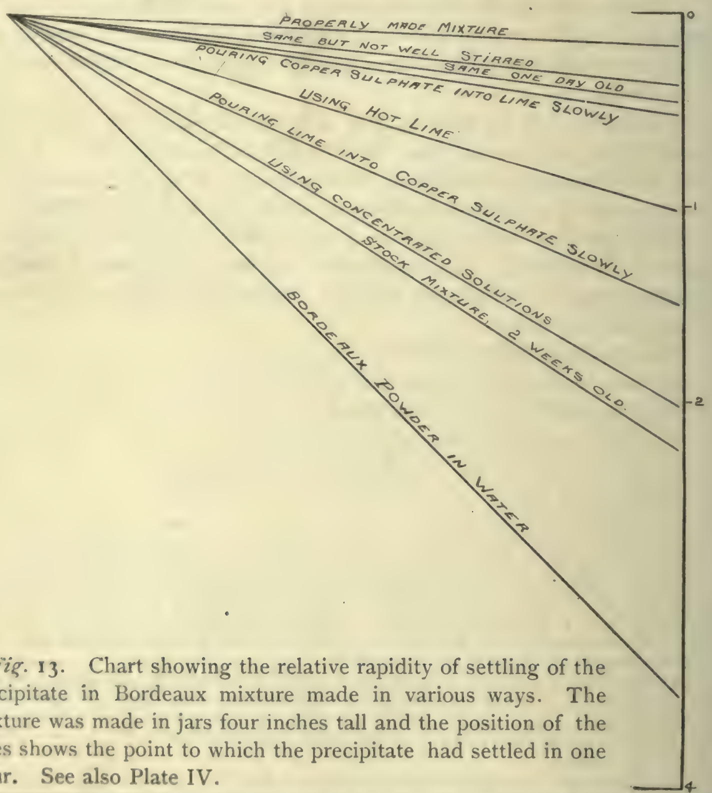

Fig. 13. Chart showing the relative rapidity of settling of the precipitate in Bordeaux mixture made in various ways. The mixture was made in jars four inches tall and the position of the lines shows the point to which the precipitate had settled in one hour. See also Plate IV.

*I. e., the blue precipitate had settled to leave only one-sixth of an inch clear water at the top.

As contrasted with the "standard" mixture more or less inferior mixtures were obtained when the process was varied in the following ways:

METHOD OF MAKING THE MIXTURES.	Per cent of the entire depth to which the precipitate settled in 30 minutes.	one hour.
1. "*Standard" mixture*	....	*4 per cent*
2. Same but less thoroughly stirred........	4 per cent	8 per cent
3. Dilute sulphate *slowly* added to dilute lime. No stirring while adding, thorough stirring afterwards........	7 per cent	13 per cent
4. Dilute solutions poured together into a third vessel. No stirring while adding, thorough stirring afterwards....	7 per cent	13 per cent
5. Concentrated lime milk added to concentrated sulphate and the mixture diluted.........	44 per cent	52 per cent
6. Concentrated lime added to diluted sulphate.......	....	15 per cent
7. Concentrated sulphate solution added to dilute lime milk	....	13 per cent
8. Lime milk at boiling heat added to sulphate.	16 per cent	26 per cent
9. Lime slacked two months previously, kept under water. Mixture properly made was of standard quality.......	....	4 per cent
10. Made by potassium ferro-cyanide test, i. e. lime milk added to sulphate in successive small amounts until solution failed to respond to the test.	50 per cent	....
11. Mixture made using same quality of lime as in 10, but adding suddenly with prompt stirring	....	4 per cent
12. "Standard" mixture 24 hours old	....	10 per cent
13. "Standard" mixtures two weeks old....	....	56 per cent
14. "Bordeaux Powder" in water............	85 per cent	....

Importance of Good Lime, Properly Slacked.

The quality of the lime and the method of slacking it have much influence upon the mixture. Thus other conditions being equal a mixture made from a poorly slacked lime settled nineteen per cent. in an hour, while a mixture made from a properly slacked lime settled only eight per cent. during the same time. Lime that had been partially air slacked gave still poorer results. The lime should be fresh, clean and firm. In slacking the best results were obtained by adding at first only a small amount of water, preferably hot, and then, as slacking begins, adding cold water in small amounts as needed, never adding much at a time nor ever allowing the lime to become dry. When too much water is added small lumps of lime are apt to be covered and remain unslacked. When the lime is fully slacked it should be diluted by adding water slowly while stirring.

SUMMARY AND CONCLUSIONS.

Properly made bordeaux mixture should be of a peculiar deep blue color and should settle very slowly. The lime properly slacked may be kept as "stock" if covered with water, and such stock lime is preferable to poorly kept or partially air slacked lime. Copper sulphate may be also conveniently dissolved in large quantities and kept as a "stock solution" to be drawn upon as needed. The best results are most surely obtained if such stock lime and sulphate solutions are much diluted before combining.

The details of their combination are also important. The more quickly and thoroughly they can be mixed the better the result, and especial care should be taken that at *no time is there an excess of free copper sulphate in any part of the mixture.* Bearing this last injunction in mind equally good results may be obtained in several ways.

1. By pouring the dilute lime milk into dilute sulphate solution very quickly and then stirring thoroughly.

2. By pouring the dilute sulphate solution quickly into the dilute lime milk, then stirring thoroughly.

3. By pouring the dilute sulphate solution slowly into the dilute lime milk and thoroughly stirring while adding.

4. By pouring the two together into a third vessel so that the two streams meet, stirring meanwhile until thoroughly mixed.

In all cases thorough and long continued stirring improves the mixture.

In ordinary practice it is not practicable to obtain the best results by pouring the lime into the sulphate. (No. 1 above.) The best method to follow then is either to pour the two dilute solutions together carefully while stirring, or to pour the diluted sulphate into the diluted lime, stirring meanwhile. In this dilution it may be inconvenient to dilute the sulphate solution with one-half the total amount of water, in which case two-thirds of the water may be added to the lime and only one-third to the sulphate with good results, but the sulphate should not be more concentrated than this. If obliged to add the lime *slowly*, it is found that adding concentrated lime slowly to dilute sulphate gives better results than adding dilute lime slowly to the dilute sulphate.

Hot lime milk gives an inferior mixture, but a slight degree of warmth is not injurious. In practice diluting the freshly slacked lime with cold water will cool it sufficiently.

The smaller amount of lime needed to satisfy the potassium ferro-cyanide test gives a mixture of standard quality, so far as its physical properties are concerned at least, providing the ingredients are combined properly, i. e., quickly with thorough stirring. As usually made, however, it is distinctly inferior. Its physical qualities are rapidly impaired, hence so far as possible it should be made up fresh as needed. Where old mixture is used greater pains than usual should be taken to keep it thoroughly stirred during use.

2. A FIELD TEST OF VARIOUS FORMS OF BORDEAUX MIXTURE ON POTATOES.

Our experience last summer served to strengthen our previous conviction on the following points:

First, that it pays to protect both early and late potatoes in Vermont with fungicides as well as insecticides.

Second, that no other fungicide yet devised is at all equal to bordeaux mixture for use on potatoes.

There are, however, various forms of bordeaux mixture concerning the relative values of which we are frequently questioned. Experiments made at this station and elsewhere have shown that the bordeaux mixture of medium strength, and freshly prepared as used, is superior to any other form for practical use on potatoes. The studies of the previous article serve to emphasize and explain in part the reason for this. Certain other forms of the mixture are, however, more conveniently made or applied, and the question arises whether the advantages thus offered will not out-weigh the loss in quality of the mixture. We are often asked for example, whether it will not do as well to make up in concentrated form as much mixture as will be needed for the season, and take from this "stock" mixture and dilute as needed for use. The question also is raised, whether when through spraying the residue of the mixture should be kept and used in the next application or whether it should be thrown away.

The use of the dry powder guns for applying paris green is meeting so much favor that many have asked whether bordeaux mixture could not be prepared in the form of dry powder and applied with these guns in the same way as is done with paris green.

In order to have experimental evidence upon these points one-half acre of potatoes was set aside in 1895 for a test of the comparative values of the following forms of bordeaux mixture:

1. "*Standard*" *Bordeaux Mixture*, freshly made as used. Ingredients: 1½ pounds of copper sulphate, 1 pound of lime, 10 gallons of water. This is the mixture we have been recommending for practical use for the past year.

2. "*Test*" *Bordeaux Mixture*, freshly made as used. Ingredients, the same amounts of copper sulphate and water as in the standard mixture, (No. 1), but only enough lime added to neutralize the copper sulphate, as shown by testing with a solution of ferro-cyanide of potassium.

It has been our experience in preparing the mixture by this test that only about one-half as much lime is needed as is used in the standard mixture, that is to say, this "test" mixture actually contained in each ten gallons of water, 1½ pounds of copper sulphate and about one-half pound of lime.

3. "*Stock*" *Bordeaux Mixture*, prepared at the beginning of the spraying season in July. This was made in the same way as the standard mixture except that only one-half as much water was used. This stock mixture was allowed to stand in open vessels during the summer. At the time of each application it was thoroughly stirred and from it as much as wished for immediate use was dipped out and diluted with equal parts of water so as to make it of the same strength as the standard mixture.

4. "*Bordeaux Powder*." This was prepared by making standard bordeaux mixture as in No. 1, which was then allowed to stand until the blue precipitate had settled. The clear water was then poured off the top, the blue precipitate thoroughly dried and then ground between millstones to the finest possible powder. The powder was applied in the following ways:

(*a*). Dry and undiluted.

(*b*). Dry, after dilution with wheat flour in proportion of 1 part of powder to 3 parts flour.

(*c*). With the spray pump after mixing with water in the proportion of 1 pound of the powder to 4 gallons of water. This mixture of the powder in water exactly equals in chemical strength the "standard" bordeaux mixture (No. 1, above).

5. "*Fungiroid*." A powder similar to the above, prepared and sold as a fungicide by Leggett and Brother of New York City. This was applied in the following ways:

(*a*). Dry and undiluted.

(*b*). Dry after dilution in the proportion of one part of the Fungiroid to three parts flour.

The field was planted May 20th with four varieties of potatoes, viz.: Beauty of Hebron,* Rural New Yorker No. 2, White Star and Polaris. These variety plots extended in rows running north and south. The plots were staked for experimental spraying crosswise of these rows so that each sprayed plot included all four varieties. As laid out in this way there were fifty-one rows to be used in the test. Each third row of these was left untreated as a "check," while the remaining rows were treated with the various fungicides under test as shown in the following page.

The liquid mixtures were applied with a knapsack spray pump at the rate of about 125 gallons per acre in the first applications, and as the plants increased in size the amount was increased to about 200 gallons per acre in the third.

The amount of dry powders used was made to agree as nearly as practicable with this, being applied at the rate of about 40 pounds per acre, using for the purpose a Leggett powder gun. Forty pounds of the dry bor-

* Owing to the poor "seed" the stand of Hebron potatoes was so irregular that the yields are not given.

deaux powder contains the same amount of copper sulphate and lime as 160 gallons of the standard bordeaux mixture.

A glance at the following page will show that the check rows and those sprayed with the standard bordeaux mixture were so scattered across the field as to give an opportunity to use both for close comparison in determining the relative value of each of the other methods of treatment. The idea governing this plan was that this bordeaux mixture would serve as the highest standard of excellence and that the "check" rows would represent the lowest limit. The results showed this presumption to be correct. The potatoes were purposely planted late in order to avoid complications with the various insect and early blight attacks of July. Three applications of each fungicide were made; the dates of applications being as follows: first, July 25th; second, August 13th; third, August 31st.

The late or Phytophthora blight was later than usual in appearing, the first indication of its presence being detected about September 1st. From this date until the last of the vines were killed by frost, about October 10th, this disease continued its depredations, the check rows being all killed off by the middle of September, and the others dying in the order indicated below. October 1st, before a killing frost came, a critical examination of the field was made and from the appearance of the tops alone the various fungicides were graded in the following order as to relative value:

First, "Standard" Bordeaux mixture; in excellent condition.

Second, "Test" Bordeaux mixture; distinctly inferior to rows sprayed with the standard mixture, although looking very well.

Third, "Stock" Bordeaux mixture; very uneven in appearance, some in fairly good condition, others entirely dead.

Fourth, "Bordeaux powder" applied in water; very uneven, some fairly good, others dead.

Fifth, "Bordeaux powder" and "Fungiroid" applied undiluted as dry powders; these gave about equally poor results, the plants in both cases being nearly dead.

Sixth, "Bordeaux powder" and "Fungiroid" diluted with flour and applied dry; plants were entirely dead and the rows indistinguishable from the "check" or untreated rows.

The results upon digging were even more convincing than the appearance of the vines. Owing to the continued progress of the disease for some weeks after the last spraying was done, there was considerable loss from the rot even where the bordeaux mixture was used. Another application of this mixture in September would have prevented much of this and would have been very profitable. Since some of the plants treated with weaker

PLAN OF POTATO FIELD SPRAYED EXPERIMENTALLY.

ROW NO.		Yield of tubers of marketable size in lbs.	
		SOUND.	ROTTEN.
141	Sprayed with "Standard" Bordeaux Mixtures..	185.	11.8
142	Check, i. e., no fungicides applied..	111.	27.8
143	"Standard" Bordeaux mixture.............. ..	159.7	14.7
144	"Test" Bordeaux mixture (No. 2,).............	159.7	9.3
145	Check, no fungicide.........................	118.7	61.6
146	"Standard" Bordeaux mixture.........	157.4	20.5
147	"Stock" Bordeaux mixture	141.4	30.7
148	Check, no fungicide (No. 3,).................	110.4	43.7
149	"Standard" Bordeaux mixture.................	156.0	19.9
150	Bordeaux powder, dry, undiluted (No. 4 a,)....	85.	69.3
151	Check, no fungicide.........................	52.9	55.2
152	Bord. powder, dry, diluted with flour (No.4 b,)..	60.4	70.
153	Fungiroid, dry, diluted with flour (No. 5 b,)..	56.8	78.5
154	Check, no fungicide....	59.4	78.7
155	Bordeaux powder, dry, undiluted..............	74.5	84.2
156	Fungiroid, dry, undiluted....	87.8	53.2
157	Check, no fungicide..........................	88.9	59.2
158	"Standard" Bordeaux mixture...	142.3	33.2
159	Bordeaux powder in water (No. 4 c,)...........	151.1	31.
160	Check, no fungicide...........	50.1	70.
161	"Standard" Bordeaux mixture..	127.4	32.4
162	"Test" Bordeaux mixture......................	120.5	21.9
163	Check, no fungicide..........................	84.1	84.4
164	"Standard" Bordeaux mixture..	145.5	25.5
165	"Stock" Bordeaux mixture.....................	100.3	53.
166	Check, no fungicide.........................	61.5	86.8
167	"Standard" Bordeaux mixture...............	141.9	34.9
168	Bordeaux powder, dry, undiluted...............	100.1	70.4
169	Check, no fungicide	62.9	71.3
170	Bordeaux powder, dry, diluted with flour......	76.1	83.1
171	Fungiroid, dry, diluted with flour.............	67.7	71.6
172	Check, no fungicide...................	76.4	80.3
173	Bordeaux powder, dry, undiluted..............	71.8	70.4
174	Fungiroid, dry, undiluted	77.3	66.2
175	Check, no fungicide..........................	83.8	55.3
176	"Standard" Bordeaux mixture.........	146.7	32.1
177	Bordeaux powder in water	124.5	83.3
178	Check, no fungicide..........................	58,1	97.6
179	"Standard" Bordeaux mixture.	158.	34.9
180	Bordeaux powder, dry, undiluted..	109.7	56.1
181	Check, no fungicide...........	94.5	71.
182	Fungiroid, dry, undiluted.....................	72.	74.
183	"Test" Bordeaux mixture.....................	109.3	48.
184	Check, no fungicide.	102.1	46.3
185	"Standard" Bordeaux mixture.................	142.5	27.3
186	Bordeaux powder, dry, undiluted.............	94.4	59.3
187	Check, no fungicide..........................	91.1	47.5
188	Fungiroid, dry, undiluted....................	92.9	40.4
189	"Test" Bordeaux mixture	132.2	37.9
190	Check, no fungicide..........................	80.	67.1
191	"Standard" Bordeaux mixture...............	241.7	27.2

fungicides were already dead it was impracticable to make a uniform application to all and therefore none were sprayed after September 1st.

The yields of both sound and rotten tubers are given for each row on the preceding page. A glance at these will show that there was a considerable difference in soil conditions between the two ends of the field. This was known when the experiment was planned and the frequent insertion of both check rows and those sprayed with standard Bordeaux mixture was made in order to meet this difficulty.

In order to judge of the relative value of any treatment it is easily compared with these rows lying near it on either side. After a careful study of the results the following table has been made as representing fairly the relative protection afforded by the various fungicides named. The yields are translated into bushels per acre in order to make them more intelligible to the average reader.

TABLE SHOWING RELATIVE PROTECTION FROM USE OF VARIOUS FUNGICIDES.

TREATMENT.	AVERAGES TAKEN FROM ROWS.	YIELDS IN BUSHELS PER ACRE.	
		LARGE SOUND TUBERS.	LARGE ROTTEN TUBERS.
Standard Bordeaux mixture..................	143, 146, 161, 164, 179, 185	389.	67.
"Test" Bordeaux mixture....	144, 162, 189, 189	349.	78.
"Stock" Bordeaux mixture...	147, 165	322.	112.
Bordeaux powder, dry, undiluted.............	158, 155, 168, 173, 180, 186	235.	182.
Fungiroid, dry, undiluted	156, 174, 182, 188	220.	156.
Check, no fungicide.....	average of all...........	219.	168.

Conclusions. With these figures before us there can be no hesitation in drawing the following conclusions:

Standard Bordeaux Mixture (1½ lbs. copper, 1 lb. lime, 10 gals. water,) ***freshly prepared as used*** is so distinctly superior to all others that it alone should be used.

"*Test*" *Bordeaux Mixture* (1½ lbs. copper sulphate, 10 gals. water, lime added by potassium ferro-cyanide test [about ½ lb. lime used]) was not equal to the standard mixture.

7

"*Stock*" *Mixture*, or old mixture, is so distinctly inferior to the others that its use should be avoided so far as practicable, i. e., one should always aim to make up no more of the mixture than is to be used immediately.

Bordeaux Powders. The last remarks apply equally to the bordeaux powder where it was applied in water with the spray pump.

When these powders were applied dry even in most liberal amounts they gave so little protection that their substitution for the ordinary or wet mixture is not to be recommended under any circumstances.

The powders as diluted with flour were much inferior to the undiluted powders.

III. DISINFECTION OF SEED POTATOES.

The following experiments were undertaken to gain more definite information upon two points:

First, The condition of the resulting crops when seed potatoes disinfected by the corrosive sublimate bath are planted on infected soil as compared with similar seed on clean soil.

Second, The effect of the disinfection upon "germination" and yield.

Three series of plots were planted with similar seed, in each of which a portion of the seed was disinfected and a duplicate portion not disinfected.

Series One was planted on *clean* soil, the disinfected seed widely separated from the infected in order to test the efficacy of the disinfection under proper conditions.

Series Two was planted on old *infected* soil, the disinfected seed and that not disinfected being well separated from each other in order to determine the effect of disinfection where the crop is grown upon old soil. The effect of the treatment upon "germination" and yield was also observed.

Series Three was planted on similar soil to that used in series two but disinfected and untreated seed were used in *alternate rows* in order to more closely compare the results of treatment on "germination" and yield.

Disinfection was performed in all cases by freeing the potatoes from dirt by washing, followed by immersion for one and one-half hours in a solution of 2 1-4 ounces of corrosive sublimate in 15 gallons of water.

SERIES ONE.

The seed designated as "scabby" in the following account was as bad as was obtainable, the condition in some cases rendering good "germination" doubtful. The soil used for this series was unquestionably perfectly free from germs of the scab. It was nearly a mile from any house and had recently been covered with pine forest. No crop had been planted since the removal of the pines.

The various lots of potatoes were scattered so as to preclude danger of

germs being carried from infected to disinfected plots in soil water. But little cultivation was given the plants and that little was with the hoe which lessened the chance of carrying germs from plot to plot as compared with horse cultivation.

The conditions of the seed and of the resulting crop were as follows:

No. of row	VARIETY.	CONDITION OF SEED.	TREATMENT OF SEED.	PER CENT. OF SCABBY TUBERS.
1	Polaris	Scabby:......	None.........	33
2	"	"	Disinfected ..	7
3	White Star..	"	None	22
4	" " ..	"	Disinfected ..	.......None
5	Unknown....	Very Scabby.	None.........	57
6	"	" "	Disinfected ..	12
7	New Green...	Smooth.. ...	" ..	........None
8	E'rly Worther	"	" ..	........None
9	B'ty Hebron.	"	None.........	5
10	Snowflake ...	"	"	20

The results show clearly that disinfection of very scabby seed even after careful cleaning did not insure a perfectly clean crop even on a virgin soil, (rows 2 and 6.) The reduction in amount of scab in all such cases is very great, however (rows 1, 3 and 5), the average amount of scab in the crop from such untreated seed being 37 per cent. while in the corresponding rows from disinfected seed the amount of scab is reduced to 6 per cent. The results further show that where smooth seed was used after disinfection a perfectly clean crop was secured (rows 7 and 8.) Where, however, smooth seed was used without disinfection more or less scab resulted. (rows 9 and 10.) Although rows 9 and 10 were not of the same varieties as 7 and 8 there is no reason to suspect that the results would have been different had these varieties been used.

SERIES TWO.

This was designed to test the effect of the disinfection of the seed potatoes upon their "germination" and upon the condition of the resulting crop, both as to scabbiness and yield, when planted upon *infected* soil. The soil had been in grass for some years prior to 1894, when it was thoroughly manured and planted to tomatoes. Adjoining land planted that year to potatoes had produced a somewhat scabby crop from clean seed, indicating an infected soil.

The details as to conditions and results are shown in the following tables:

SMOOTH SEED USED.

VARIETY.	PER CENT OF SCABBY TUBERS.	
	UNTREATED.	DISINFECTED.
Rural New Yorker	11.5	3
Early Puritan	55	21
Polaris	37.5	17
White Star	10	10
Averages	28.5	12.8

SCABBY SEED USED.

VARIETY.	PER CENT OF SCABBY TUBERS.	
	UNTREATED.	DISINFECTED.
Rural New Yorker	34	15
Early Puritan	50	5
Polaris	49.5	18
White Star	28	24
Unknown	66	20
Averages	40.4	15.5

The plots were planted May 25. On June 11 it was noted that "the germination of the disinfected potatoes is plainly retarded in all cases. Those disinfected are now just breaking through the soil while the plants in the adjoining rows not disinfected are three and four inches high."

The effect of disinfection of seed upon scabbiness is evidenced by the figures in the above tables. In all cases there is a decided reduction in the amount of scab found in the resulting crop, this reduction being on the average, where smooth seed was used, from about 28 per cent. to 12 per cent., and where scabby seed was used from 40 per cent. to 15 per cent.

In no case was there perfect freedom from scab, nor was this to be expected owing to the infected condition of the soil. There was no effect upon yield from the treatment that is worthy of note.* The total yield of

* Our results last year (Vt. Exp. Sta. Rep. 1894, p. 106) indicated a considerable gain from the disinfection of scabby seed. It is possible that this larger gain in 1894 was due to the fact that the seed then used was more badly diseased than that used in 1895.

large tubers from the disinfected and from the corresponding untreated rows averaging as following:

Yield of rows, untreated seed, 1507 tubers weighing 763 pounds.

Yield of rows, disinfected seed, 1417 tubers weighing 789 pounds.

SERIES THREE.

This was designed to test the effect of the disinfecting upon "germination" and yield, the disinfected and untreated seed being planted in alternate rows so as to allow closer comparison than was possible in the more isolated plots of series two. It was to be expected that this proximity would lessen the gain from the disinfection so far as concerns scabbiness of the resulting crop, and also that it might interfere with a possible gain in yield from the disinfection. The results fully bear out the first expectation, at least, as shown in the following summary of results. All seed tubers used in this series were free from scab spots.

VARIETY.	TREATMENT OF SEED.	TUBERS FREE FROM SCAB.	TUBERS SCABBY	TOTAL.
Houlton Rose....	Untreated.	189	137	326
" "	Disinfected.	271	60	331
Extra Early Vt...	Untreated.	117	17	134
" "	Disinfected.	118	38	156
White Star......	Untreated.	338	68	406
" "	Disinfected.	384	48	432

The totals from this table are as follows, with the addition of total weights:

Untreated, 866 tubers, weighing 203 pounds; 644 smooth, 222 scabby.

Disinfected, 919 tubers, weighing 193 pounds; 773 smooth, 146 scabby.

The disinfected seed tubers were slow in starting growth as in the case of series two. The yield from the untreated seed tubers is slightly greater than from the disinfected tubers, but the difference is not great enough to be noteworthy. The condition as regards scab is in line with the results from series two but has little experimental significance owing to the proximity of the rows planted with treated and untreated seed.

GENERAL SUMMARY OF RESULTS FROM DISINFECTION EXPERIMENTS.

First. Smooth seed, but taken from a crop having more or less of scab, when planted on clean soil, gave a somewhat scabby crop, although much less so than did scabby seed.

Second. Smooth seed, disinfected and planted on clean soil gave a perfectly clean crop.

Third. Very scabby seed washed and disinfected in the same way gave a crop slightly scabby, but very much less so than did similar untreated seed.

Fourth. Smooth seed, disinfected, planted on infected soil produced a crop considerably cleaner than untreated seed, but in no case was it entirely free from scab.

Fifth. Disinfection of the seed performed just prior to planting in all cases retarded the "germination" and apparently weakened the young plants.

Sixth. There was no apparent gain or loss in total yield, large enough to be significant, attributable to disinfection of seed.

In view of the fifth conclusion stated above, it would seem probable that the soaking of the seed tuber in the corrosive sublimate solution just before planting injures or at least retards the starting of the young sprouts. It is probable that this is due to the injurious action of the poison on these sprouts, and that the more advanced sprouts are more liable to injury than those in a more dormant condition. If this is the correct explanation it follows that the disinfection should be performed earlier, either the previous fall or during the winter, instead of being delayed until just before planting time, as is the usual practice. The earlier disinfection will prevent scab equally well, provided care is taken not to reinfect them in the subsequent stirring and handling of the seed potatoes. Such poisoned tubers should always be plainly labelled to prevent danger from their use as food.

IV. ORCHARD DISEASES AND REMEDIES.

I. SPRAYING PEARS WITH BORDEAUX MIXTURE.

In 1894 about 35 apple trees and 3 Flemish Beauty pear trees in the orchard of Miss Lydia M. Root, South Hero, were sprayed under our directions, and the results noted in our last annual report (page 109). The benefits from that work were so evident as to convince all who saw the crop of the value of the spraying. It is easily understood moreover that the thorough disinfection of a tree by such spraying should insure a more healthy crop for the succeeding season—thus the beneficial effects of spraying the tree should prove in a degree cumulative from year to year. In order to observe whether this occurs to an appreciable degree the same trees were sprayed in the same manner this season (1895), and it is planned to continue the work similarly in 1896. As 1895 was not the bearing year for apples it was not possible to judge of results upon these, but the Flemish Beauty pear trees bore well and showed marked improvement where sprayed, the fruit being even more perfect than in 1894.

The benefits resulting from the applications of 1894 were apparent before the work of 1895 began, all of the sprayed trees being easily recognized by

the cleaner and brighter color of the bark on trunk and limbs. It was also noted that the buds on the sprayed trees started earlier and more vigorously. The trees were sprayed four or five times, as follows:

April 23, before buds opened; sprayed with solution of one pound of copper sulphate in 15 gallons of water.

May 10, leaves expanded; sprayed with bordeaux and paris green mixture.

May 30, petals just fallen; sprayed same as before.

June 12, sprayed same as before.

June 26, sprayed pear trees No. 1 and 2, as before, leaving pear No. 3 without further spraying.

Scab spots were found on the leaves and young fruit of the unsprayed trees at the date of the last spraying, but none on those of the sprayed trees.

The pears bore well and the fruit was gathered August 30. As before stated, there was so little fruit upon the apple trees that no attempt was made to judge its condition accurately, although there were evident benefits from the spraying.

The three Flemish Beauty pear trees which were sprayed bore eight barrels of fruit, which, together with two barrels borne by an adjoining unsprayed tree, was carefully sorted, with the following striking results:

FRUIT FROM TREES NO. 1 AND 2, SPRAYED FIVE TIMES.

1st barrel,	547	pears,	first class;	25	second class.
2nd "	626	"	"	1	"
3rd "	676	"	"	2	"
4th "	582	"	"	3	"
5th "	643	"	"	7	"
6th "	734	"	"	5	"
Total,	3808	"	"	43	"

The apparent cause for the inferior condition of the 43 pears sorted out as second class was as follows: 16 shrivelled by fire blight; 9 injured by limb bruises; 13 under size; 4 russeted, possibly by the mixture; *1 scabby.*

Tree No. 3, sprayed four times, showed the following condition of fruit:

1st barrel,	614	pears,	1st class.	8	2nd class.
2nd "	627	"	"	7	"
Total,	1241	"	"	15	"

Of these 15 second class pears, four were scabby, the other eleven being inferior because of small size or limb bruises.

In contrast with these results the following were found on the unsprayed tree:

1st barrel,	618	pears,	1st class.	119	2nd class.
2nd "	559	"	"	129	"

The second class fruit was only about half size and was badly scabbed and cracked.

The inferior condition of the fruit designated as "first class" from this tree as compared with that from the sprayed trees was also very striking, since all of the fruit from the unsprayed trees was more or less scabby, while that from the sprayed trees was entirely smooth.

In order to learn more exactly the effect of the scabby condition of the fruit upon its market value, a barrel of the "first class" fruit from each the sprayed and the unsprayed trees was shipped to the New York market, directed to L. S. Davis, a commission merchant, for his judgment. His reply was that the market was crowded with pears and prices very low, but that while the unsprayed fruit was worth $1.75, that from the sprayed tree was worth $2.25.

The results may then be briefly summarized as follows:

When the trees were sprayed nearly 99 per cent. of the fruit matured perfect and entirely free from scab, and only one scabby pear was found in the six barrels of fruit where the trees were sprayed five times, and but four scabby pears in two barrels of fruit where the tree was sprayed four times.

Practically every pear borne on the unsprayed trees was scabby, nearly 19 per cent. of the fruit was worthless for marketing, and the remaining 81 per cent. was decidedly inferior to that from the sprayed trees,

When placed on the New York market the sprayed fruit was valued at $2.25 as contrasted with $1.75 for the best of the unsprayed fruit. The relative values of the crops from the sprayed and unsprayed trees is then easily computed as follows:

A barrel of fruit from the unsprayed tree has 81 per cent. of marketable fruit, worth $1.75 per barrel. Value, $.81 \times \$1.75 = \$1.42$.

A barrel of fruit from the sprayed tree has 99 per cent. perfect fruit, worth $2.25 per barrel. Value, $.99 \times \$2.25 = \$2.23$.

The gain from spraying is then 81 cents on each barrel of fruit which is equivalent to $1.50 to $2.50 per tree as the crop ran in this orchard, a very profitable return for the four sprayings necessary to secure this result.

II. FROST INJURIES TO APPLES AND PEARS.

The following letter sent to the Experiment Station from Vergennes, Vt., under date of August 13, 1895, is typical of a number of inquiries received last summer and autumn:

"We send you to-day samples of apples showing a diseased condition which has attacked our fruit for the first time. We should like to learn if it is a new trouble and what can be done to prevent it. It has attacked all kinds of apples, but is worst on the Greenings. It starts as a small spot and spreads, often covering the entire apple, the growth being checked by it. It seems to be worse on the east side of the trees. The rapidity with which it has spread in the last ten days causes us to fear that it will injure the

sale of the fruit. Can we do anything to stop it this year and how shall we check its return another year."

The skin of the apples received was badly russeted over the surface from one-third to one-half the distance back from the apex towards the stem. On some the russeted area formed a band or zone extending partially or entirely around the apple midway between apex and stem. The injury was even more common on the pears brought from about Burlington into the city markets than it was upon apples. The accompanying figures are photographs of injured Bartlett pears, showing the characteristic russet zones.

Fig. 14. A Bartlett pear showing frost band.

Many fruit growers attributed the russeting to injury from solutions used in spraying them, yet on inquiry it was found that unsprayed trees suffered equally with sprayed ones. The injury was unquestionably due to a late frost. Similar injury was observed by the writer upon fruit in Canada, New York State and as far west as Wisconsin.

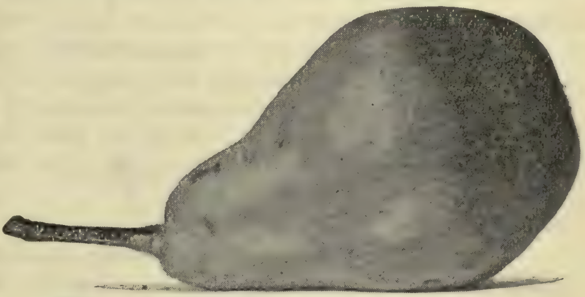

Fig. 15. A Bartlett pear showing frost injury at apex.

Mr. G. H. Powell, of Cornell University, writing in *Garden and Forest*, Vol. VIII, p. 417, regarding the trouble, says it is due to the freezing of the dew collected upon the young fruit, and Dr. Sturgis, of the New Haven, Conn., Experiment Station, in his Report for 1895, accepting this explanation, adds that the broadening of the injured zone later during the growing period of the fruit is due to continued rupturing and rehealing of the tissues adjacent to the injured area.

V. SOME OBSERVATIONS REGARDING OAT SMUT.

I. RELATIVE AMOUNTS OF SMUT IN OATS GROWN IN VERMONT AND IN MORE WESTERN STATES.

Determinations of the per cent. of smutty oat plants found in a large number of fields in Vermont during several years past have shown that as a rule the oat crop of Vermont is much freer from this disease than is that of most sections of the country. This difference is in especial contrast with the large amount of oat smut occurring in most of the Western States.*

As a result of our observations it was stated in the Report for 1893, p. 65, that the evidence from all sources points to the conclusion that "*certain conditions affecting the oat crop in Vermont are unfavorable to the development of smut as compared with the conditions of many, if not most, of other sections of the country.*"

Since the smuttiness of the crop is largely dependent upon the condition of the seed, the above conclusion, if correct, should lead Vermont farmers to avoid the use of Western oats of unknown origin for seed.

In order to learn more fully the facts regarding this difference in occurrence of smut and to collect other data which might help to explain the reason for such conditions, letters were sent to officers of various Experiment Stations asking them to co-operate by sending seed oats from their States, containing, if possible, a considerable per cent. of smut, and to sow some of the same at their own stations. Each was further asked to note the climatic conditions prevailing at his station during the period when the oats were germinating and when they were in flower.

Samples were received as follows:

South Dakota, sent by T. A. Williams, four samples.
Wyoming, sent by Aven Nelson, one sample.
Wisconsin, sent by E. S. Goff, one sample.
Michigan, sent by C. F. Wheeler, one sample.
Ohio, sent by A. D. Selby, five samples.
Illinois, sent by G. P. Glinton, one sample.
Iowa, sent by L. H. Pammel, one sample.
Indiana, sent by J. C. Arthur, two samples.
North Dakota, sent by H. L. Bolley, three samples.

*The following is reprinted from our former Bulletin 32:

"The loss from oat smut in New York was estimated in 1885 at 10 per cent. of the entire crop; in Kansas, 1888–91, at 6 to 11 per cent.; in Indiana, 1891, at 10 per cent.; in Michigan, 1891, 15 per cent.; in Wisconsin, 1891, at fully 15 per cent. In view of these estimates the U. S. Department of Agriculture in a recent bulletin stated that the 'average loss is from 5 to 12 per cent. in different localities in the United States,' while another good authority, Dr. Arthur, states that this country loses annually from smut 'nearly or quite 10 per cent. of the total oat crop.'"

Our thanks are due these gentlemen for their co-operation.

The series of plats were sown at Burlington with some or all of these samples, as follows:

First Series—Ohio seed sown in green-house benches in February, maturing in June.

Second Series—All varieties sown in field in May, maturing in August.

Third Series—All varieties sown in field in July, maturing in September.

FIRST SERIES.

The seed from the Ohio station was received in the winter. A small portion of the seed from each of the five varieties was at once sown in our green-house, February 5, to determine the development of smut under these peculiar conditions. The plants grew very luxuriantly, but did not reach the flowering and fruiting stage in as short time from sowing as did those grown out of doors. In June, when fully headed out, the per cent. of smut* on these was found to be as follows:

Variety.	Per cent. of Smutty Stalks.
Race Horse,	15.6
Black Norway,	15.6
Mammoth Russian,	8.7
American Banner,	8.7
Black Prolific,	11.5

SECOND SERIES.

On May 4th one plat of each of the varieties received from the various stations, together with several plats of Vermont grown seed, were sown on well drained clay soil. The seeding was done with a horse drill, which placed the seed at a pretty uniform depth of one and one-half inches. In July, as the plants became fully headed out, the per cents of smut were determined by counting sound and smutty stalks in one drill of each plat. The results obtained from these countings are included in the following table, to-

*A very peculiar development of smut occurred on the Black Prolific variety under the conditions of this green-house culture. The fruiting of the fungus, visible as the familiar black smutty masses, is usually confined to the flowering parts of the oat plant, viz., to the ovaries and surrounding scales or glumes. In a considerable proportion of the smutty plants of this variety, however, the sporulation occurred on the upper leaves as well as on the fruiting portions. The smutted portions were usually at the apexes of the leaves, and the epidermis over these portions was in many cases ruptured before the smutted panicle was protruded from its sheath. Upon microscopical examination these spores showed no differences from spores produced in the usual location.

gether with these reported from the home stations, where samples of seed oats were sown, duplicating those sent to our station for this trial.

Source of Seed.	Variety,	Per cent. Smut at Burlington.	Per cent. Smut at Home Station.
Illinois,	Pringle's Progress,	6.6	14
Indiana,	White Schenan,	3.8	1.
"	Black Prolific,	8.1	1.6
Iowa,	....	3.7	......
Michigan,	American Banner,	4.1	... .
N. Dakota,	Sample " No. 2,	9.6	18.2
"	" " " 3,	26.8	26.6
"	" " " 4,	19.8	18.8
Ohio,	Race Horse,	49.6	42.2
"	Black Norway,	31.2	45.2
"	Mammoth Russian,	25.2	19.5
"	American Banner,	37.7	34.6
"	Black Prolific,	29.4	31.
S. Dakota,	Dakota Grey,	37.8	23.7
"	White Wonder,	32.6	37.7
"	Jeanette Canadian,	3.6	4.
"	White Canadian,	13.6	7.3
Wisconsin,	....	6.8	2.3
Wyoming,	Bonanza,	58.8	26.
Vermont,	White Schonan,	5.7	{ .9* 3.6†
"	"Common White,"	4.4	{ .2† 5.3†
	Averages,	21.6	16.7

* Vermont seeds sent to Indiana Station and grown there.

† Vermont seeds sent to South Dakota Station and grown there.

THIRD SERIES.

July 15 a third series of plats were sown immediately adjacent to these last, and seed from the same sacks used. The oats came up well, but were soon attacked by rust and insects and made a poor growth in consequence. A fair per cent. of them headed out in September however, and were nearly mature when killed by frost. Frequent examination of these plats failed to reveal a single smutted plant.

SUMMARY OF RESULTS.

The results so far as concerns the development of smut may be briefly summarized as follows:

The Ohio seed grown in the green-house developed only about one-third as much smut as when sown out of door at the usual season.

When sown in July and maturing in September no smut whatever was developed, although the seed was from the same source as that which produced in some cases over 50 per cent. of smut when sown earlier in the season.

Comparing the amount of smut produced from Western seed sown in Vermont with that occurring where duplicate lots of seed were sown at the various Experiment Stations from which the seed was sent, the average is in most cases higher in Vermont than at the other stations. Three-quarters of the twenty samples showed a larger per cent. of smut when grown in Vermont than at the home station.

It is evident, therefore, that there were some conditions surrounding the regular oat crop grown at Burlington during 1895, which were peculiarly favorable to the development of smut. This is the more striking since our observations of previous years* had tended to show that, on the contrary, the conditions existing in Vermont usually tend to diminish the amount of smut.

It is manifestly of considerable practical importance to learn, if possible, what these varying conditions are. It is known that the fungus which causes the disease can gain an entrance only into the seedling oat plants, and that this infection usually occurs from spores which are inclosed alongside the oat kernel within the husks or glumes. The conditions which favor the germination of the oat kernel favor likewise the growth of the fungus spores, and this fungus being thus favorably situated at once penetrates the tender young tissues of the seedling oat plant Once inside, the fungus pushes its way to the point of active growth in the apical bud and in its growth keeps pace with the growth of the plant until the time of the oats flowering, when the fungus appropriates the nutriment elaborated by the oat plant and produces therefrom a mass of its own dusty spores. From the time of germination there exists, we may suppose, a contest within the tissues of the oat plant, the oat striving to outstrip its unwelcome associate in its growth that it may mature its normal fruit. There is evidence of this in the hastened maturity of oat plants infected with the smut, such plants "heading out" earlier than their more fortunate fellows. That the oat tissues do in some cases at least partially outstrip the fungus in this race is shown by the fact that it is not uncommon to find the lower portion of the cluster or panicle of oats smutted

*See Vt. Exp. Sta. Rep. 1893, p. 65.

while the upper portion has escaped the disease, having, as Dr. Brefeld has explained, grown away from the fungus.

With these facts regarding the life history of the fungus in mind it is evident that surrounding climatic or soil conditions may at any point in the contest so favor one or the other of the contestants—either the oat or the smut fungus—as to decide which shall come out victorious. Thus it is possible that the conditions of the soil at the time of the germination may favor one more than the other, or that conditions existing later during the period of combined growth of the oat plant and fungus may tend to give one or the other the advantage.

It has been shown by European investigators that the conditions of temperature during the period of germination directly determine the ability of the smut fungus to enter the seedling plants. It was, therefore, assumed at the beginning of our work that differences in soil temperature during the period of germination might, in some measure at least, account for differences in per cents of smut in the resulting crop.

The various other Experiment Station workers were, therefore, asked to contribute data concerning the conditions surrounding the germinating grain. Many kindly complied with this request. The statements are upon so different bases, however, that exact comparisons are impossible. We, therefore, give only those surrounding the germinating oats at our station, viz., soil temperatures and rainfall, and leave the results unexplained.

SOIL TEMPERATURES, FIRST SERIES, OATS RAISED IN GREEN-HOUSE.

Sown February 5. Temperature taken by setting bulb of thermometers in the soil to the same depth as seed lay. The average temperatures as registered by three thermometers in different parts of the beds follow.

Dates.	*Temperatures in degrees Fahrenheit.*						
	6 A. M.	8 A. M.	10 A. M.	12 A. M.	3 P. M.	7 P. M.	10 P. M.
Feb. 6.	..	..	49	53	53	48	45
" 7.	41.4	44	59	61	60	50	45
" 8.	47	48	49	56	53	49	47
" 9.	47	48	49	56	55	50	49
" 10.	47	48	59	68	68	60	55
" 11.	48	50	59	66	71	59	57
" 12.	53	56	65	66	65	58	57
" 13.	52	54	60	64	53	54	53
" 14.	52	..	68	68	74	58	54
" 15.	50	..	66	68	..	64	52
Extremes	53 43	50 44	68 47	68 53	71 53	64 48	57 45
Averages,	48	50	58	62	62	55	51

Oats began to appear above ground February 12, and were 1 to 3 inches high by February 15.

SOIL TEMPERATURES, SECOND SERIES.

The second series planted in the field May 4 had soil temperatures taken only three times daily, each reading given below being the average of the temperatures taken at five different points in the field by means of a thermometer with bulb sunk in the soil to the depth where seeds lay and allowed to remain there five minutes before reading was taken.

May 6, 5½ P. M. average 24.5°.

Dates.	*Temperatures in degrees Fahrenheit.*		
	6½ A. M.	1½ P. M.	7 P. M.
May 7,	63	81	75
" 8,	64	84	70*
" 9,	64	84	81
" 10,	71	88	76
" 11,	65	87	75
" 12,†	55	54	49
Extremes,	65 / 55	88 / 54	76 / 49
Averages,	62	80	69

May 6, first roots were just starting from seed.

May 9, first leaves appearing above ground.

May 10, nearly all plants above ground.

SOIL TEMPERATURES, THIRD SERIES.

Sown in field July 15th. First leaves appeared above ground about July 20.

Dates.	*Temperatures in degrees Fahrenheit.*		
	6½ A. M.	1½ P. M.	7 P. M.
July 16,	63	68	65
" 17,	65	84	75
" 18,	64.5	85	72
" 19,	64.5	86	73
" 20,	70	92	77
" 21,	70	93	78
Extremes,	70 / 63	68 / 93	78 / 65
Average,	66	84	73

* Heavy rain.
† Cold rains all day.

2. THE GENERAL OCCURRENCE OF OAT SMUT IN VERMONT IN 1895.

In continuation of similar observations of previous years, the amount of oat smut was observed in a number of fields about Burlington aside from the experimental plats previously described. The result of the examination of nine such fields in South Burlington, all of which had been sown with seeds oats obtained from some seedsman and a numb er of which were known to be "Western" seed was as follows;

Total number of panicles, 3140; number of smutty, 102.

The per cent. of smut (3.25) is higher than in most previous years. Nine fields in this vicinity examined in 1894 showed 1.7 per cent. of smut, while the highest per cent. found in any field was 7.5, some smut being found in all of the fields.

In addition to these observations a circular letter was sent to a number of farmers about the State asking that samples be taken from their oat fields* and sent us for examination as to amount of smut.

In reply samples were received from thirty-eight different localities. A careful examination of these for smutty panicles showed that:

Fourteen were entirely free from smut; six had less than 1 per cent.; nine had from 1 and 2 per cent.; five had from 2 and 3 per cent.; one had from 3 and 4 per cent.; two had from 4 and 5 per cent.; one had from 5 and 6 per cent. of smut.

The average amount of smut in the 38 was 1.49 per cent.

The average of the entire 47 examined in 1895 was 1.9 per cent.

In comparison with this the average amount found in 81 samples examined in 1892 was 1.6 per cent. of smut and of 97 examined in 1893 this average was .76 per cent. of smut. By inquiry it was found that ten of the thirty-eight men who sent samples in 1895 had been using the same strain of seed continuously since 1892, and an opportunity is thus afforded for a more exact comparison of the relative smuttiness of the crops from the same strains of seed for the three years in which we have full data in our reports, viz.: 1892, 1893 and 1895. Averaging the results from these ten fields for each of the three years the results are as follows:

Average amount of smut from ten fields 1892, .36 per cent.

Average amount of smut from same strains 1893, .4 per cent.

Average amount of smut from same strains 1895, .57 per cent.

Conclusions. The results all indicate some variation in the amount of smut in the same strain of seed from year to year and further that there was more smut than usual in the oat crop throughout the State in 1895.

As heretofore only a very small per cent. of smut was found in the fields of painstaking farmers using home grown seed. A considerably larger per cent. nearly always occurred where "Western" oats were used for seed.

* Similar requests had been sent to many of these men in 1892 and 1893. The directions for taking the samples were similar to those of 1893. See Rep. Vt. Exp. Sta. 1893, p. 62.

VI. THE ONION MILDEW IN VERMONT

In 1889 serious trouble from an onion disease apparently of a fungus nature and variously designated as "blight," "rust" and "smut" was reported by onion growers from various sections of the State.* No specimens were obtainable then and although vague rumors have reached us from time to time no specimens or information from which the nature of the disease could be determined have been received previous to this year.

In September, 1895, a letter from E. E. Herrick, Jr., of Milton, stated that his onions were dying rapidly from a blight and asked advice as to the cause and remedy. A visit was made to Mr. Herrick's field where it was found that the most of the leaves of the onions were either dead or dying. The diseased leaves were more or less completely covered with a dirty greenish gray powdery mildew which was so uniformly associated with the disease even in the earliest stages as to at once indicate that it was the cause. A miscroscopic examination of this fungus confirmed the belief that it was the "onion mildew," long known and dreaded by European onion growers. This mildew was reported also a few years ago as very destructive to the onion crop in the Bermuda islands. It has been previously reported as occurring upon the North American continent in only a few scattered localities. [Madison, Wis , (1883); Ithaca, N. Y., (1889); Weathersfield, Conn., (1889); Ottawa, Canada, (1889.)] The cause is the fungus *Peronospora Schleideni, Ung.* which is closely related to the fungus which causes the late blight and rot of the potato.

As it was too late to attempt preventive measures in this field the appearance of the diseased plants was noted and the history of the occurrence of the disease learned. This was Mr. Herrick's first experience with onions on a large scale, but a neighbor who had grown the crop for years stated that the disease was usually more or less troublesome to him especially on soil where onions had been grown for several years in succession, and that in his own field, where onions had been raised the previous year also, the mildew had destroyed all his plants several weeks before it did those upon Mr. Herrick's land. As no onions had been grown before on Mr. Herrick's land to his knowledge it seems probable that the disease was conveyed to this field by spores, carried by the wind or insects from the blighting plants on his neighbor's farm. These spores are exceedingly delicate and short lived, but in compensation for this are produced in enormous numbers.

In considering how to combat this fungus successfully it becomes evident then that two courses are open to us. The first consists in learning more definitely how and where the fungus lives through the winter, and hav-

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* Fourth Rep. Vt. Exp. Station, 1890, p. 141.

ing learned this to attempt to destroy it before it attacks the succeeding crop. The second is by means of fungicides applied as sprays or otherwise to protect the healthy leaves from infection by spores from diseas ed plants.

Experiments will be undertaken along this second course the coming summer, trial being made of bordeaux mixture and other fungicides and it is suggested that any fearing the disease make trial of the same.

It seems quite probable that as much or more good may be accomplished by preventive measures as mentioned in the first course above, viz.: after having learned how and where the fungus lives through the winter to try to prevent its reaching the succeeding crop. Fortunately others have already given a considerable information regarding this matter.

The fungus may pass the winter in two ways and probably only two. The first way is by penetrating and living in onion bulbs upon which, if they are set in the garden in the following spring, an abundant crop of spores will be produced and from these the disease may be started afresh.

The second way in which the fungus may live through the winter is by means of resting or winter spores (*Oospores*) which are longer lived and more resistant to cold and similar adverse conditions than are the common summer spores

Such spores are of common occurrence in related species of fungi and have been found in the case of this onion fungus in Europe and Bermuda. Their occurrence in this country has not been previously observed, and Professor Dudley, after studying the disease at Ithaca was of the opinion that the disease as it occurred there was propagated by the fungus hibernating in the bulbs.

Mr. Herrick believes that the fungus in these fields is probably not propagated thus by means of diseased bulbs, as few or no bulbs are planted and the disease is most troublesome on onions grown from seed. Moreover, miscroscopic examination of the diseased onion leaves taken from these plants at Milton revealed an abundance of the resting spores in all stages of development. These facts indicate that the fungus here at least is perpetuated from season to season by means of these resting spores. The observation already noted that the disease begins its attacks and is most severe on soil that has grown onions the previous season, also favors this idea.

In order to test the correctness of this conclusion a barrel of soil has been scraped from the surface of a field at Milton where onions have been grown for two succeeding years and brought to Burlington. Here it has been strewn over the surface of a portion of a green house bench and onions are being grown (December, 1895,) from seed upon it, while others are growing upon

uninfected soil in an adjoining bench. The results will be awaited with interest.*

If the above conclusion proves correct that the disease is propagated over winter by such resting spores which are produced in the leaves of diseased onion plants, then much can be done in the way of prevention by carefully gathering all such diseased leaves in the autumn and burning them. If this were carefully and thoroughly done it is probable that the infection of the soil could be prevented so that a crop of onions could be safely grown on the same piece a second season. Unless such precautions are taken, however, some other crop should be grown on the infected soil for at least one year that the fungus may be starved out.

VII. THE HAWKWEED.

Mention was made in our last Report (page 114) of several weeds which are already troublesome pests or are threatening serious invasion of our State.

Unquestionably the worst of these recent invaders is the golden hawkweed or ladies' paint brush, ***Hieracium aurentiacum.*** This is already thoroughly established in roadsides and fields of northwestern Vermont and is each year spreading into new sections. In many localities its rapid spread and the difficulty of its extermination has caused serious alarm.

Considerable correspondence upon its prevalence and means of eradication led us to undertake experiments to test the best means of quickly killing it in grass land. These experiments will be continued another season before detailed publication is made, but they clearly justify the following conclusions:

First. The hawkweed can be completely exterminated in less than one year by plowing. followed by clean culture so persisted in as to allow of no continued growth of the plant above ground.

Second. Salt applied to the plants kills them very quickly and the amount necessary to do this is not sufficient to materially injure the grass.

We recommend, therefore, the use of salt, applied liberally broadcast, in all cases where a limited amount of the weed is to be exterminated.

Where a large area of tillable grass land is infested and is to be cleared, it seems probable that an application of the cheapest grade of salt obtainable. about one or two tons per acre, will prove profitable before the land is plowed, this to be followed by clean cultivation of a hoed crop.

It is hoped that a bulletin treating of this weed will be ready for publication during 1896 or early in 1897.

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* The delayed publication of this report enables us to add that the mildew appeared in April upon the plants growing in the soil taken from the onion field while the other plants growing upon clean soil are entirely free from the mildew.

REPORT OF THE ENTOMOLOGIST.

BY G. H. PERKINS.

The past year has been unusually prolific in insect pests. Probably the character of the season last year and the dryness of the early part of the present year have much to do with this. As a rule a dry season is more favorable to the increase and development of injurious insects than a wet one. Climatic conditions, the amount of rain, degree of heat and cold, and the like, affect very profoundly the increase of many insects. This alone is not the cause of periodic outbreaks of insect hordes or of their sudden disappearance, or of the great abundance of this or that species during one season or more, and then its disappearance or at least scarcity during other seasons. There are many other conditions than those afforded by the weather to be considered in investigating the lives and characters of our insect foes, but, perhaps, no conditions are more potent in the case of many species than those found during periods of unusual heat or cold, drought or flood.

Not only are many kinds of injurious insects greatly affected by climatic conditions as to their increase and growth in a given locality, but their range and spreading from one region to another is also determined largely by the same thing. Certainly there are many other conditions which must not be overlooked, any of which may in given cases determine the increase and spread, or the decrease and restriction of injurious insects. Very important among these is the presence of parasitic insects which often so prey upon injurious species that these latter are held in check by this means alone. It is often one of Nature's compensations that, while injurious species, by reason of the more abundant supply of food afforded them by cultivation of crops, are able to increase enormously and to become a serious menace to the prosperity of the man who cultivates the crops, this very increase of the harmful species soon causes a corresponding increase in species that either prey upon them directly or are parasitic and thus indirectly but surely destroy them. It is everywhere the food supply which more largely than anything else decides the increase or the destruction of forms of life. Insects that for ages, no one can tell how many, have fed upon a limited supply of wild plants and, because the supply of food was limited, have been themselves limited in increase, suddenly discover that man has interfered with the equilibrium of Nature and by his cultivation of certain plants has vastly enlarged the food supply. This discovery once made, the insects are not slow to take advantage of the new state of things and, leaving their long-restricted supplies, they swarm forth to devour the richer and more luxuriant crop regardless of the fact that it has been grown not for them, but for man. Now for a time,

785 pounds increase in live weight sold for	$30.03
1,818 pounds of corn meal, and 247 pounds of bran cost	14.21
6,295 quarts of skim milk were worth	$15.82

or twelve cents per 100 pounds.

712 pounds increase in live weight sold for	$26.79
1,119 pounds of corn meal, and 802 pounds of bran cost	12.65
6,137 quarts of whey were worth	$14.14

or eleven cents per 100 pounds.

Fifteen cents per hundred was the average of all the results on skim milk. It should be remembered, however, that when fed in moderate quantities (six quarts per day), returns were better than when freely fed (twelve quarts per day); also that the former method proved profitable even at the unprecedented low price of 4½ cents for dressed pork, while the latter method of feeding was unprofitable. Had grain rated at the prices of former years, all the pork would have been made at a loss.

Up to last year twenty-five cents and upwards have been obtained for skim milk as a result of this method of figuring, but the low prices and prolonged feeding of the past two years have lessened the money return and the value obtained from its use.

It is doubtful whether eleven cents per hundred is not too high a figure at which to rate the feeding value of whey. Bran replaced corn meal in the whey ration, thus supplying in a measure the missing protein. The lower price of the grain having the greater food value which was thus largely fed, serves unduly to inflate the money worth of the whey as well as to better the food value of the ration. On the other hand had the pigs been slaughtered earlier this figure would have been higher yet.

FERTILIZING VALUE OF FEEDS.

The materials fed these pigs were rich in plant food, and the value of the manure is an ample offset against the labor.

Skim milk and whey are worth 10 and 4 cents per hundred, corn meal $5.25 and bran $9.60 per ton as fertilizers (1896 and 1897 trade values). The total fertilizing value of the food eaten by the twelve pigs was $60.63, and it cost $112.74. Its fertilizing value was therefore 54 per cent. of its market price as food, a large proportion of which may be saved by proper handling.

REPORT OF THE BOTANIST.

L. R. JONES.

The subjects claiming principal attention during the past year have been as heretofore plant diseases and their remedies. This year marks the satisfactory completion of the laboratory work upon the potato blights. Diseases of the apple as well as maladies of several less important crops have also received further investigation. And, finally, a large amount of time and energy have been devoted to the study of the orange hawkweed or "paint brush," particularly by Mr. W. A. Orton, of the class of 1897 of the agricultural department of the University of Vermont, largely in connection with the preparation of his thesis for graduation. The practical results of this investigation were made available in Bulletin 56, which publication has aroused considerable popular interest and elicited much correspondence, not only regarding the hawkweed but also other weed plants, their present distribution, channels of introduction, methods of eradication, etc. Field and laboratory work are now in progress looking towards an increase in knowledge upon these points.

Valuable assistance was rendered in the laboratory studies of the summer of 1896 by Mr. A. J. Grout and in the field by Mr. Orton. A large share of the results based upon their work was published in the ninth report, which proportionately abbreviates the present issue, which really represents the work of but little more than half a year.

The results of the more important investigations made in the botanical department since the last report are discussed in the following order :

I. Potato Diseases and Remedies.
   1. Potato Diseases as they occurred in 1896.
   2. Studies upon the Fungi associated with Early Blight.
   3. Tests of various forms of Bordeaux Mixtures.
   4. The Effect of Disinfectants upon the Growth of Potatoes.

II. Orchard Diseases and Remedies.
   1. Results from Spraying with Bordeaux Mixture.
   2. Apple Scald.

III. Observations upon Oat Smut.

IV. The Onion Mildew.
   1. Laboratory Studies upon the Fungus.
   2. Field Experiments with Fungicides.

V. The Orange Hawkweed or "Paint Brush."

I. POTATO DISEASES AND REMEDIES.

1. POTATO DISEASES AS THEY OCCURRED IN 1896.

The warm rains early in August gave climatic conditions which led to the belief that the late blight fungus would soon begin a rapid and destructive development. These favoring conditions changed, however, before the disease got started, and did not again occur. As a result there was no outbreak of this disease at Burlington, and very little of the dry rot has been found in the potato bins during the winter. The various other blights of the potato occurred much as in 1895.*

The observations and conclusions of past years were fully sustained as to the relatively large destruction of potato foliage by arsenical poisoning (from improper use of Paris green), and by the trouble which we have termed "tip-burn." Reports from other parts of the country strengthen the belief that this latter trouble is very general, and everywhere confused with the true early blight.

2. STUDIES UPON THE FUNGI ASSOCIATED WITH EARLY BLIGHT.

The essential results of the laboratory studies of 1895 and of the summer of 1896 were included in the report for 1895. Two species of fungi commonly found on blighting potato leaves are there figured and described. One, heretofore known as *Macrosporium Solani* E. & M., has been shown to be the cause of the early blight. The other closely resembles this first, but has proved to be a saprophyte, and, therefore, nearly or quite harmless. The intimate association of the two and their close resemblance has led to much confusion regarding them, as is explained in the last report. As noted also therein the parasitic species known heretofore as a *Macrosporium* was found in some cases to produce its spores in chains, which necessitates that it be called an *Alternaria*. Since Dr. Paul Sorauer has already described this species as *Alternaria Solani*, Sorauer, it should hereafter be so designated In order to define clearly the species, we insert the following technical description:

ALTERNARIA SOLANI (E. & M.) Sorauer, Zeitschrift fur Pflanzen Krankheiten, **6**: 6. 1896.

Macrosporium Solani E & M. American Naturalist, **16**: 1003. 1882.

Macrosporium Solani Cooke. Grevillia, **12**: 32. 1883.

Conidiophores dark brown, erect or ascending; somewhat curved, septate, 50–90 by 8–9 microns; conidia obclavate, brown, 145–370 by 16–18 microns, terminating in a very long hyaline septate beak, equalling fully one-half the length of the spore (often exceeding this), body of spore with 5–10 transverse septa, longitudinal septa few or lacking.

Common and destructive as a parasite on leaves of the potato (*Solanum tuberosum*), also on tomato (*Lycopersicum esculentum*), and Jamestown weed (*Datura Stramonium*).

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*Rpt. Vt. Exp. Sta., 9 (1895), p. 78.

The following is, so far as we know, a complete bibliography of Alternaria Solani (E. & M.) Sorauer:

Ellis, J. B. Am. Nat. **16** : 1003. 1882.
Botanical description of the fungus as occuring on dying leaves of potato at Newfield, N. J.

Cooke, M. C. Grevillia. **12**: 32. S 1883.
Describes this fungus on Datura Stramonium as Macrosporium Solani Cooke.

Galloway, B. T. Gard. and Fld. Je 1891. (Adelaide, Australia.)
Records injury to potato plants by this fungus observed in U. S. in 1890 and in 1891 and successful use of bordeaux mixture as a preventive.

Humphrey, J. E. A New Potato Disease.
Rpt. Mass. State Exp. Sta. **9**: 226. 1891.
Records destructive potato leaf-blight associated with and apparently caused by this fungus.

Chester, F. D. A Leaf Blight of the Potato.
Rpt. Del. Exp. Sta. **4**: 58-60. *f.* 4-7. 1891.
Describes the fungus and states that it occurs on potato causing serious leaf-blight, also on tomato. Records results of inoculation experiments with the fungus on tomato leaves.
——— A Leaf Blight of the Potato.
Bul. Del. Exp. Sta. 15: 13-14. Ja 1892.
Practically a reprint of the preceding.
——— Diseases of the Round Potato and their Treatment.
Rpt. Del. Exp. Sta. **5**: 67-70. 1892.
Records destructive occurrence of this fungus and results of experiments in use of bordeaux mixture as a preventive.

Fletcher, J. Potato Blight.
Rpt. Canada Exp. Farms. **6**: 163-164. 1892.
Records destructive occurrence of this fungus upon potatoes at Ottawa, 1892, and usefulness of bordeaux mixture as remedy.

Halsted, B. D. Rpt. N. J. Exp. Sta. **13**: 326. 1892.
Notes occurrence of this fungus as a partial parasite on tomato fruits.

Jones, L. R. The New Potato Disease or Early Blight.
Rpt. Vt. Exp. Sta. **6**: 66-70. *pl. 4*. 1892.
Description of the "early blight" apparently due to this fungus.

Sturgis, W. C. Diseases of the Potato.
Rpt. Conn. Bd. Agr. **27** : 228-230. 1893.
Popular account of early blight, recommending the use of bordeaux mixture.

Pammel, L. H. Experiments to prevent certain Leaf-spot Diseases of the Potato. Bul. Ia. Exp. Sta. **20**: 719-720. F 1893.
Notes occurrence of blight and the association of Macrosporium with it; also gives results of field trial with bordeaux mixture as preventive.

Galloway, B. T. The Macrosporium Potato Disease.
Agr. Sci. **7**: 370-382. Ag 1893.
Detailed review of observations to date upon the fungus, with account of laboratory studies, artificial cultures, inoculations and results of field experiments with various fungicides and preventives.

Jones, L. R. Potato Blights and their Remedies.
Bul. Vt. Exp. Sta. **36**: 1-4. *f. 3-5.* A 1893.
Popular description of early blight as distinguished from the late blight (Phytophthora) and recommendations regarding use of bordeaux mixture.

Rolfs, P. H. Bul. Fla. Exp. Sta. **21**: 36-37. O 1893.
States that fungus occurs destructively on leaves, stem and fruit of tomato, and that tests show bordeaux mixture to be efficient remedy.

Goff, E. S. Rpt. Wis. Exp. Sta. **10**: 245-246. 1893.
Describes a potato blight attributed to the attacks of this fungus and gives results of experiments with bordeaux mixture as preventive. (For more popular account of the same work see Bul. Wis. Farm Inst. **7**: 76-77. *f. 1-2.* 1893.)

Jones, L. R. Rpt. Vt. Exp. Sta. **7**: 42-43 and 46. 1893.
Notes on occurrence of early blight of potatoes and discussion of the causal relation of the Macrosporium to it. Experiments showing the value of bordeaux mixture as a preventive.
———Bul. Vt. Exp. Sta. **40**: 20-21. D 1893.
Popular discussion of results given in last reference.

Lamson, H. H. Rpt. N. H. Exp. Sta. **5**: 166-168. 1893.
Popular account of the blight of potatoes associated with this fungus with report on favorable results from experimental use of bordeaux mixture as a preventive.

Sturgis, W. C. Rpt. Conn. (New Haven) Exp. Sta. **17**: 74 and 101. 1893.
Mentions occurrence of the fungus; considers it an open question whether it is the primary cause of the disease.

Lamson, H. H. Early Blight.
Bul. N. H. Exp. Sta. **22**: 6. My 1894.
Discusses occurrence of disease in N. H. and probable value of bordeaux mixture as preventive.

Rane, F. W. The Leaf-blight of the Potato.
Bul. W. Va. Exp. Sta. 38: 39-40. *f. 1.* N 1894.
Notes the occurrence of the fungus in W. Va. causing destructive blight; discusses susceptibility of varieties and use of bordeaux mixture.

Galloway, B. T. The Macrosporium Potato Disease.
Farmers' Bul. U. S. Dept. Agr. 15: 4-6. *f. 2.* 1894.
Popular illustrated description of the Macrosporium potato disease with directions for use of bordeaux mixture as preventive.

Jour. (British) Bd. Agr. 1: 199-217. 1894.
Descriptive notes on potato blights and bordeaux mixture.

Halstead, B. D. Rpt. N. J. Exp. Sta. **15**: 290, 354, 359, 360. *f. 42.* 1894.
Notes spotting of tomato leaves by this fungus as the worst of tomato blights, and also states that this is the most serious fungous enemy of the potato.

Jones, L. R. Rpt. Vt. Exp. Sta. **8**: 95. 1894.
Notes upon occurrence of this fungus at Burlington, 1894.

Sturgis, W. C. Notes on "Early Blight" of Potatoes.
Rpt. Conn. Exp. Sta. **18**: 127-135. 1894.
Critical discussion of investigations to date, with conclusion that the fungus is either a partial parasite or a wound parasite.

Beach, S. A. Bul. N. Y. Exp. Sta. 86: 100 and 102. F 1895.
Notes occurrence of this fungus on potato and tomato causing blights.

Fletcher, J. Potato Blights.
Bul. Canada Exp. Farms. 23: 24. *f. 5.* Ap 1895.
Notes occurrence of fungus in Canada causing much loss.

Lamson, H. H. Bul. N. H. Exp. Sta. 27: 8-10. Ap 1895.
Discusses nature of disease and means of recognition, and gives results of use of bordeaux mixture as a preventive.

Tracy, S. M. and **Earle, F. S.** Bul. Miss. Exp. Sta. 34: 121. My 1895.
Note on occurrence of the fungus in Miss. on Datura Stramonium.

Grosjean. Le Macrosporium de la Pomme de Terre.
Bul. Minister de L'Agric. *f. 1-2.* My 1885. (Paris.)
Popular description, with figures based on various American publications.

Kirk, T. W. Some Potato Diseases and How to Prevent Them.
Leaflet New Zealand Dept. Agr. 25 : *f. 1.* Je 1895.
Figures and describes the Macrosporium disease of the potato as the most serious fungous malady of this plant in Australia and advises the use of bordeaux mixture.

Halsted, B. D. Rpt. N. J. Exp. Sta. **16**: 326, 339 and 344. 1895.
In experiments with bordeaux mixture, copper sulphate solution and potassium sulphide solution for controlling this fungus, the first gave fair results, the two latter were of no value.

Jones, L. R. Bul. Vt. Exp. Sta. 49: 91-94. *f. 1-2.* D 1895.
Popular illustrated description of the early blight contrasting the injuries from the fungus with those caused by arsenical poison and "tip burn."

———Rpt. Vt. Exp. Sta. **9**: 78-86. *pl. 1-3. f. 12.* 1895.
Detailed account of laboratory and field investigations leading to the conclusion that the fungus is a true parasite and the primary cause of the early blight, also that it is an Alternaria rather than a Macrosporium. (Issued Aug. 1896.)

Weed, C. M. Fungi and Fungicides. 164-165. 1895.
Brief popular description of potato blight caused by this fungus; bordeaux mixture recommended.

Sorauer, Paul. Auftreten einer dem amerikanischen "Early Blight" entsprechenden Krankheit an den deutschen Kartoffeln. Zeit. Pfl. Krankh. **6**: 1-9. *pl. 1.* 1896.
Records occurrence of destructive blight of potatoes in Hungary due to this fungus ; results of inoculation experiments and of laboratory studies lead to belief that it is an Alternaria.

Lodeman, E. G. Diseases of the Potato.
Bul. Cornell Exp. Sta. 113: 254-261. *pl. 1.* F 1896.
Notes destructive occurrence of early blight in N. Y. and discusses causes, concluding that the fungus is not a true parasite but attacks only weakened or injured foliage.

Stewart, F. C. Potato diseases on Long Island in the Season of 1895.
Bul. N. Y. Exp. Sta. 101: 76-77. F 1896.
Notes destructive occurrence of early blight due to this fungus, and gain from use of bordeaux mixture.

Garman, H. Potato Blight.
Bul. Ky. Exp. Sta. 61: 18. Mr 1896.
Spot disease of potatoes in Kentucky, possibly attributable to this fungus; bordeaux mixture recommended.

Jones, L. R. Potato Blights.
Gard. and For. **9**: 188-189. My 1896.
A discussion of the various causes leading to the premature dying of potato leaves.

Selby, A. D. Bul. Ohio Exp. Sta. 73: 241. D 1896.
Notes occurrence of the fungus in Ohio on tomato, causing leaf-spot.

Halsted, B. D. Rpt. N. J. Exp. Sta. 17: 355. 1896,
Records successful use of bordeaux mixture on potatoes in 1896 for controlling leaf blight.

Lodeman, E. G. The Spraying of Plants. 345-347. *f. 79.* 1896.
Describes and figures early blight of potato due to this fungus; bordeaux mixture recommended.

Stewart, F. C. Spraying Potatoes in Long Island in the Season of 1896. Bul. N. Y. Exp. Sta. 123. Ap 1897.
Discusses amount of injury by this fungus and comparative values of various fungicides in checking it.

Sajo, Karl. Beobactungen uber die Durrflecken Krankheiten der Kartoffeln in Jahre 1896. Zeit. Pfl. Krankh. 7: 4-9. 1897.
Notes upon the early blight of the potato as it occurred in Hungary in 1896.

Jones, L. R. and Grout, A. J. Notes on two species of Alternaria. Bul. Torr. Bot. Club. 24: 254-258. *f.1-2. pl. 308.* My 1897.
Summary of work upon Alternarias at Vt. Exp. Sta. in 1896 with botanical description of the fungus.

Lamson, H. H. Bul. N. H. Exp. Sta. 45: 50. My 1897.
Gives results of treatment with bordeaux mixture.

In connection with investigations upon *Alternaria Solani* Mr. Grout continued the studies during the summer of 1896 upon the puzzling species associated with it upon potato leaves described and figured in our last report.*

This should now be known as *Alternaria fasciculata* for reasons given below.† "All attempts at inoculation of living potato leaves with this fungus failed to produce infection even under the most favorable greenhouse conditions. During the summer, studies of the fungus diseases of the onion were undertaken and on some of the dead onion leaves a fungus was found so closely resembling this *Alternaria fasciculata* as to be indistinguishable from it. Spores of *Alternaria fasciculata* from a pure culture from potato leaves were sown on dead onion leaves still attached to a living plant. A rank growth of the mycelium bearing the characteristic Alternaria spores soon appeared on the inoculated spots but none elsewhere, showing the undiscriminating nature of the plant, for a fungus that will grow on dead leaves of onions and of potatoes can scarcely be restricted to any group or groups of plants.

*Rpt. Vt. Exp. Sta., 9 (1895), pp. 84-85.

†Extracted from article by L. R. Jones and A. J. Grout in Bul. Torr. Bot. Club, 24 (1897), pp. 254-258.

When later in the summer the study of tomato rots was taken up, it was found that the fungus which appears in black patches on the decaying tips of the fruit was an *Alternaria* not distinguishable from the one on the onion and the potato. It was further shown that this fungus did not cause the rot,* for green tomatoes inoculated with spores from a pure culture from the tomato remained for ten days in a moist chamber until they ripened without showing signs of rot, and cultures made from tomatoes just beginning to rot would not yield the Alternaria.

Alternaria fasciculata was found on the dead leaves of beans, cabbage, *Lathyrus palustris*, on hulls of oats and dead stems of buckwheat ; also on dead leaves of corn where it equals *Macrosporium Maydis* E. & E., on paste board, equalling *M. chartarum* Pk., on ripe pods of radish, equalling *M. fasciculatum* E. & E. Doubtless further investigations will identify many other Macrosporium species with this omnipresent saprophyte, and doubtless also an older name than the one given above will be applied to it."

To aid in clearing up this matter the following description and synonymy are added, also reprinted from the same article.

ALTERNARIA FASCICULATA (C. & E.)

Macrosporium chartarum Pk. Rpt. N. Y. Mus., **25** : 93. 1873.
(Not Preuss., 1848.)
Macrosporium fasciculatum C. & E. Grevillia, **6** : 6. *Pl. 96.* 1877.
Macrosporium Maydis C. & E. l. c. 87.
Macrosporium Tomato Cooke, Grevillia, **12** : 32. 1883-4.
Alternaria Solani, Sorauer (in part) Zeit. Pfl. Krankh, **6** : 1-9. *Pl. 1*, 1896.

Conidiophores brown, erect or ascending, irregularly curved, solitary or caespitose, septate, diameter uniform, 40-130 microns long by 3 wide ; conidia dark brown, oblong-ovate, minutely apiculate, 9-14 microns wide by 35-90 long, endochrome transversely 2-7 septate, with usually several longitudinal septa, the apical cell short or elongated into a straight somewhat hyaline beak, fruiting freely in pure cultures on nutrient media. On dead and decaying vegetable matter of many kinds.

The spores vary a great deal according to the stage of their development.

Careful comparisons were made with Ellis & Everhardt's Fungi Columbiana No. 399, *Macrosporium fasciculatum*, also with No. 396, *M. chartarum*.† There was no opportunity of comparing with *Alternaria chartarum* Preuss. which may prove to be the same thing.

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*It is worthy of note in this connection that Selby, (Bul. Ohio Exp. Sta., 73 (1896), p. 241), speaking of the rot of tomatoes usually attributed to this fungus, expresses the opinion as the result of his observations and experiments that this "point rot" is associated with insufficient moisture in the soil, and that "lack of moisture is a condition, if not a cause of this form of green rot." This would place the disease in the same category as the tip burn of potato leaves which has the same fungus associated saprophytically with it.

†Specimens growing on old pasteboard were submitted to Mr. C. H. Peck who replied as follows: "The specimen you send is evidently the same as that which I called *Macrosporium chartarum*. Your investigations appear to me to show clearly enough that these genera [Macrosporium and Alternaria] are one and cannot both be kept alive."

3. TESTS OF VARIOUS FORMS OF BORDEAUX MIXTURE.

Twenty-four rows of potatoes were reserved for experimental spraying in continuation of the work of former years. In order to justify closer comparisons every other row was left unsprayed as a check. Upon the remainder the following fungicides were tested:

1. *Standard Bordeaux Mixture:** Copper sulphate 1½ lbs., lime 1 lb., water 10 gals.

2. Bordeaux mixture with one-half the usual amount of lime, i. e. copper sulphate 1½ lbs., lime ½ lb., water 10 gals. This amount of lime is sufficient to neutralize the sulphate, the standard mixture having a large excess of lime.†

3. Bordeaux powder, consisting of the precipitate of standard bordeaux mixture dried and ground into a very fine powder. This was applied dry with a "powder gun."

The averages of the entire series are as follows in pounds per row:

	Large tubers.	Small tubers.
Standard bordeaux mixture	108.6	7.7
Half-lime bordeaux mixture	110.9	8.0
Bordeaux powder	81.2	7.8
Check (no fungicide)	85.8	9.2

The gain from spraying with bordeaux mixture was about 24 lbs. per row, or 28 per cent. It should be remembered that this gain occurred in spite of the fact that there was no late blight (Phytophthora) or rot. It emphasizes again the truth that it *will repay every potato grower to spray his entire field every year*, whether the late blight is feared or not.

The main questions in the experiment are, however, as to the relative values of the two forms of bordeaux mixture and of the bordeaux powder. There can be no doubt as to the last. The average yield of the rows where the powder was used was less than that from the checks. Examination of the yields in detail justifies the belief that this apparent loss may be due to unavoidable variations resulting from inequalities in soil, etc. There is no doubt, however, that this powder is practically worthless as a fungicide for use on potatoes. This is in full accord with our results of former years,‡ and with similar tests at other stations.§

The other question raised in this experiment is as to the relative values of the standard and of the half-lime mixtures. The average is slightly in favor of the half-lime mixture. A closer examination of results shows that in two of the four cases where the two fungicides may be fairly compared, the

*Made by diluting both the sulphate solution and the lime-milk with one-half of the total water used, and pouring the sulphate solution into the lime while stirring vigorously. This gives the best mixture known. (See Ninth Report, p. 89).

†Rpt. Vt. Exp. Sta., 9 (1895), pp. 92 and 97.

‡Rpt. Vt. Exp. Sta., 9 (1895), p. 98.

§Bul. N. Y. Exp. Sta., 123 (1897), pp. 253-254.

standard mixtures gave larger returns than did the adjacent half-lime mixture, while in the other two cases the half-lime mixture gave the better returns. The results from the two are therefore so nearly identical that it may safely be concluded that there is practically no choice between them.

It becomes then merely a matter of convenience as to which mixture shall be used. The half-lime mixture is somewhat more desirable in that the smaller amount of lime present decreases the trouble from clogging of nozzles by the mixture. On the other hand one is running near the danger line in using so little lime. If the lime should be very poor or impure, the smaller amount might not neutralize the sulphate, and the mixture would be quite certain to injure the plants. It is therefore safer, and on the whole better as a rule, to use the standard mixture unless one is sure of the good quality of the lime employed, or is prepared to test the mixture in some way so as to determine that all the copper sulphate is neutralized.

The half-lime mixture does not color the sprayed plants so deep a blue, and for this reason there are cases when it is much to be preferred to the standard mixture. This is especially true where ornamental plants are to be sprayed, or where there is danger of staining fruit.

4. THE EFFECT OF DISINFECTANTS UPON THE GROWTH OF SEED POTATOES.

Our experience of the past few years has led to the belief that the disinfection of seed potatoes with corrosive sublimate solution, as practiced for the prevention of the scab, may retard the "germination" or early growth of the potato plants.*

In most cases injury has not been sufficient to be worthy of account, the plants from the disinfected seed quickly overtaking those from the untreated seed. In some cases, however, the results have been more disastrous. This has been especially true when the conditions of soil or weather were unfavorable to the young plants or when the seed tubers were of low vitality, more especially when the tubers had sprouted considerably before planting. This effect was very apparent in 1896 when a period of very dry weather followed planting. We quote from our ninth report :

"Disinfection of the seed [by corrosive sublimate] performed just prior to planting in all cases retarded the germination and apparently weakened the young plants. It is probable that this is due to the injurious action of the poison on the sprouts and that the more advanced sprouts are more liable to injury than those in a more dormant condition. If this is the correct explanation it follows that the disinfection should be performed earlier, either the previous fall or during the winter instead of being delayed until just before planting time as is the usual practice."

A series of experiments to test the correctness of these conclusions was carried out during the winter and spring of 1896. These experiments were repeated in 1897 and similar tests were made of the formalin solution recom-

*Rpt. Vt. Exp. Sta., 9 (1895), p. 102.

mended by Arthur* as a substitute for the corrosive sublimate. In all cases tubers of uniform weight and appearance were selected early in the winter and laid aside for this work. In the experiments of 1896 four varieties were used, in 1897 only two varieties.

The plan both seasons was to disinfect in the same manner at successive dates and observe the effect upon the early growth. The planting was done May 23 in 1896 and May 10 in 1897.

The complete records of germinations would make a confusing series of tables, and therefore we present only the averages as follows:

SEASON OF 1896. Disinfection by soaking one and one-half hours in 1-1000 corrosive sublimate solution (2¼ ounces in 15 gallons of water.)

Number of days after planting.	PER CENT. OF TOTAL NUMBER OF PLANTS ABOVE GROUND AT FROM NINETEEN TO THIRTY DAYS FROM PLANTING.			
	Untreated.	Disinfected on day of planting.	Disinfected 46 days before planting	Disinfected 96 days before planting.
19	6	1	6	4
20	20	5	17	22
21	31	12	31	31
24	76	67	72	78
30	93	91	97	94

SEASON OF 1897. Corrosive sublimate disinfection as in 1896; formalin disinfection by soaking tubers two hours in 1-607 formalin solution.

(Eight fluid ounces of 40 per cent. formalin [the usual commercial strength] to 15 gallons water.)

Number of days after planting.	PER CENT. OF TOTAL NUMBER OF PLANTS ABOVE GROUND AT FROM NINETEEN TO THIRTY DAYS FROM PLANTING.					
	Untreated.	Cor. Sub. on day of planting.	Cor. Sub. 44 days before planting.	Cor. Sub. 76 days before planting.	Formalin on day of planting.	Formalin 15 days before planting.
21	47	20	38	57	47	45
23	78	57	75	72	85	84

Final germination was practically perfect in all cases.

Everyone who has had experience in careful tests of potatoes will realize the large sources of error in field work of this character. Making full allowance for these and disregarding smaller differences there can be no doubt as to the correctness of the following conclusions:

*Bul. Ind. Exp. Sta., 56 (1895); Bul. do. 65, (1897).

1. Disinfecting with corrosive sublimate just before planting retarded the early growth of the plants both seasons.

2. Similar disinfection performed from one and one-half to three months before planting had no such effect.

3. Disinfecting with formalin had no retarding effect but apparently slightly stimulated growth.*

As already stated the slight injury here shown may not influence the ultimate stand of plants or the yield. We have had no appreciable evidence that it has done so in our plots except one year (1895.) Under some circumstances unquestionably it may do so. Moreover the amount of injury to the seed must naturally depend largely upon its condition at the time of treatment. If in the best of condition, that is with no sprouts started, the injury will be proportionately lessened. In our own cellar we are not able to keep potatoes from throwing out some sprouts and this should be taken into consideration in interpreting the results. The gain from the use of the disinfectant would in any case outweigh the possible losses.

Its use a month or more before planting time should remove all difficulty in any case. The relative effects upon subsequent growth of the formalin and of the corrosive sublimate solutions will lead us to prefer the former in case it proves equally effective in preventing scab as indicated by Arthur's experiments.

II. APPLE SCALD.

The apple crop of 1896 was a remarkably large one in Vermont, and there were numerous complaints that the fruit did not keep as well as usual. These facts led us to devote some time to the study of the causes of the decay of stored fruits, and, especially, of Greening apples. A number of troubles or diseases were commonly found contributing more or less actively to the destruction of the fruit, among them being the scab, the bitter rot, and the brown spot, the latter being especially troublesome on Baldwins. There was also a considerable disfigurement of fruit by hailstones during the heavy storm which occurred the latter part of August. It is interesting to note, however, that these bruises led to no hastened decay in any cases observed, save where the skin of the apple had been cut by the hailstones.

Another trouble, the serious occurrence of which in Vermont was first observed by us this year, is the fly speck fungus,† which often covered the fruit with its sooty blotches. These troubles were all of secondary importance, however, when compared with the so-called "scald."

THE SCALD.

This trouble, although widespread on Greenings, and generally known by this name, merits description that it may not be confused with some other

*Similar good effects were observed by Bolley (Bul. N. Dak. Exp. Sta., 27 (1896), p. 164), attending the germination of smutted grain treated with formalin in order to kill the fungus.

†*Leptothyrium pomi* M. & F.

malady. Greening apples which appear perfectly sound at time of harvest, will, at varying periods from midwinter on, become discolored. A light brownish tinge appears at first either in fairly well defined spots or more or less diffused over the surface. These discolored areas enlarge with more or less rapidity, fusing together until the entire surface of the apple may be involved. At the same time the color passes from a lighter to a dark brown shade, and usually terminates in a black rot. Upon cutting into the apple at the beginning of the trouble the flesh appears white and sound, the discoloration involving only the outer cells of the peel. As the trouble advances, however, the discoloration penetrates deeper into the flesh of the apple, and is soon followed in most cases by the fungus invasion, which we have just described as the black rot. This fungus is clearly a secondary affair, however, the primary discoloration being due to a breaking down of the tissues following their death from some cause other than the invasion of any fungus or other parasitic organism.

Our attention was first called to the serious occurrence of this trouble the past winter by Mr. T. L. Kinney, of South Hero, and at his invitation a visit was made to a number of the cellars and houses where Greenings were in storage in his vicinity. This was in February. In some cellars nearly the entire crop had been rendered unsalable, and was destined to early decay; in others scarcely a trace of the scald was seen. At first thought the trouble was deemed to be the result of improper conditions surrounding the stored fruit. Further comparisons showed, however, that this alone could not account for the entire difficulty.

There is much difference of opinion and a general lack of understanding among orchardists as to what the exact cause or causes are which are to be held primarily responsible. Doubtless they are numerous. Mr. Kinney believes that we must look for at least a portion of them in the conditions which surround the fruit before it is gathered, and others of our best practical orchardists are of simuar opinion.

ORCHARD CONDITIONS WHICH MAY LEAD TO THE SCALD.

Mr. Kinney's theory is that the apples are prepared to scald by conditions existing in the orchard, and he was able to show that the fruit in his vicinity freest from scald was from orchards where the trees were relatively the younger and the better situated, in brief, those in which the trees were in most vigorous condition.

Professor Bailey also is inclined to emphasize the responsibility of orchard conditions, and he states in correspondence that his observation has been that "the scald is worse when the fruit becomes rather over-ripe in the fall." He finds it "very bad when the falls are warm and dry, and the Greenings ripen up early."

Professor Goff, of Wisconsin, writes that his observations indicate that the scald has been much more prevalent in some seasons than in others.

Hon. George T. Powell, of Ghent, N. Y., has given much thought to the relation of orchard conditions to the keeping qualities of fruit, and lays much emphasis on the relation of scald to conditions preceding picking. We quote from a recent letter from him: "I am becoming convinced that the conditions before harvesting have much to do with the development of scald. If the season is one in which the fruit is steadily developed to the time of maturity without passing through extremes of temperature, that is normally developed, I think there will be little trouble from scald.

"For several years insects have very greatly injured the foliage of apple trees, fully one-half of the foliage has been destroyed by leaf-eating insects. As a result the fruit has been imperfectly grown, and it has been more susceptible to fungus attacks and early decay. Since I have been spraying to protect the foliage from fungus and insect attacks, my fruit ships much better, and I have less scald and decay. The past year was exceptional. From April 16 to 20, 1896, we had excessive heat, which brought vegetation forward unnaturally. Fruit matured during the hot weather of August and September, and it had poor keeping qualities. The Greening is one of the first of winter apples to mature, and it could neither be shipped to Europe nor kept in cold storage last winter successfully. If it is well grown it can be kept longer; if it is checked in its growth or is forced by continued hot or dry weather, it will scald before it decomposes. When perfectly grown I have seen it carry through a long period, and decompose without the development of scald. I have known the Greening to be kept two years in cold storage with no scald, but the fruit was perfectly grown."

Such testimony leaves no doubt as to the importance of using all practical means by fertilizing, cultivating, pruning and spraying, to bring the fruit to perfect maturity as the first step in the prevention of the scald.

There was, however, abundant evidence in the fruit cellars visited that the conditions surrounding the stored fruit have much to do, at least, in hastening or retarding the development of the scald.

RELATION OF CONDITIONS IN THE STORE-ROOM TO THE DEVELOPMENT OF THE SCALD.

In some of the cellars visited in February and March practically every Greening was scalded, while in others every apple was sound. In the case where the scald was worst the owner had been unable to keep the cellar at a sufficiently low temperature, and the excessive scald was, in his own opinion and in that of his neighbors, due to the high temperature. The one cellar visited which was entirely free from the scald was high and dry, with relatively less fruit in it and quite well ventilated. It should be noted, however, that the orchard from which this fruit was harvested was exceptionally well situated.

The relation of temperature and ventilation to scald is clearly shown in the fact of common observation that when the Greenings are stored in open barrels the scald, when it appears, shows first upon the fruit in the core of the barrel, and even when the fruit in the interior of the barrel is quite badly scalded, the upper layers for six inches or more may remain fresh and sound. Mr. H. D. Allen, of South Hero, states that when he has stacked barrels of Greenings in two tiers in his cellar, the fruit in the upper barrels was scalded worse than that below.

Mr. Kinney, whose storehouse was built with special reference to preserving uniformity of temperature and of ventilation, suffered considerably from scald during the past winter in spite of the fact that during the winter months he was able to hold the thermometer quite uniformly between 33° and 35°. He attributed his misfortune to conditions in the orchard as before stated, but observed some differences in amounts of scald in different portions of his house.

Through the kindness of Mr. S. A. Beach, of the New York State Station, we were placed in communication with Mr. T. B. Wilson, of Hall's Corners, N. Y., who has had a great deal of experience in handling Greening apples. He states that he has known Greenings kept in single barrels in a dry house cellar that did not show the scald by the first of April, while fruit from the same lot treated in the same way, except that the barrels were put in storage with many others, began to scald in January or February. He believes that in general a large lot of apples stored together will not keep as free from scald as will single barrels. He further writes that in his experience apples will scald much quicker if they are packed in the barrel immediately after picking and forced to sweat there than they will when allowed to sweat in a pile, and then after drying packed in the barrel. Mr. Wilson kindly outlined his method of handling the fruit with reference to lessening scald as follows: "We think the best place to sweat the apples is in the orchard. We put two or three inches of straw under the pile, and locate the pile in the shade, or at least so that the hot sun of the middle of the day cannot strike the apples. (Red apples we pile in the sun, and in that way get more color). The piles are made ten inches or a foot deep. The number of barrels in a pile does not matter. We place from five to forty barrels together as is most convenient, aiming not to make the pile too wide. They are usually left in the pile from two to three weeks. When we get them into storage we get the mercury, as soon as we can, down to about freezing, and aim to keep it as near that point as is possible." Mr. Wilson further believes that there is a possible advantage in shelving or crating Greenings while in storage instead of barreling them. He cites the experience of Mr. P. Gleason, of LeRoy, N. Y., who has had a considerable experience in this line, and who, by transferring Greenings from barrels to crates and stacking these crates in his cellar, has succeeded in keeping them from scalding much longer than when in barrels.

There is evident need of further comparison of practical methods along the lines suggested by the experience of Messrs. Wilson and Gleason, and it is hoped that those readers who have had such experience will write us regarding it.

III. OBSERVATIONS UPON OAT SMUT.

In the spring of 1895 seed oats were obtained from various western states and sown at this station in a series of plots in order to compare the relative amounts of smut developed under the changed climatic conditions. The seed harvested from each of these plots in 1895 was saved and again sown upon the same plot in 1896, the object being to continue the study of the original problem and more especially to see to what extent the smut would spread from one plot to another. The plots were each six feet wide, with two feet open space between.

The arrangement of the plots with the amounts of smut found in each in 1895 and in 1896 are as follows :

Source of Seed in 1895.	Variety.	Per cent. of smut, 1895.	Per cent. of smut, 1896.	Source of Seed in 1895.	Variety.	Per cent. of smut, 1895.	Per cent. of smut, 1896.
Vermont	White Schonan.....	4.7	12.4	Ohio	Mammoth Russian..	25.2	19.6
"	Black Oat..........	0.0	8.4	Vermont	White Schonan.....	7.6	6.6
"	Common White.....	4.7	12.3	Ohio	American Banner...	37.7	22.5
Indiana	White Schonan.....	3.8	19.9	"	Black Prolific.......	24.4	26.0
"	Black Prolific.......	8.1	25.5	Wisconsin	....	6.8	15.4
No. Dakota	No. 2	9.6	21.8	Wyoming	Bonanza............	50.8	42.8
"	No. 4	19.7	20.7	So. Dakota	Dakota Grey........	37.8	24.3
"	No. 3	26.8	28.1	"	White Wonder......	32.6	62.5
Iowa	....	3.7	9.3	"	Jeannette Canadian.	3.6	4.4
Illinois	Pringle's Progress...	6.6	8.7	"	White Canadian.....	13.6	15.5
Michigan	American Banner...	4.1	9.9	Vermont	Black, Old Seed.....	0.8	7.7
Ohio	Race Horse.........	45.6	25.7	"	Common White.....	4.5	5.7
"	Black Norway......	31.2	27.2	"	White Schonan.....	5.3	3.6

These results clearly show that the smut spreads rapidly from plot to plot under favorable circumstances. This is made more evident by comparing a few averages. Thus the average of all the plots shows 16.4 per cent. of smut for 1895 and 15.7 per cent. for 1896, a slight decrease in smuttiness. In contrast with this the average from all the plots sown with Vermont seed shows in 1895 3.9 per cent. while in 1896 the amount has increased to 8.1 per cent., or more than doubled. The amount of the disease in the very smutty plots showed a corresponding decrease; for example in the case of the seed obtained from Ohio the averages in 1895 were 34.6 per cent. while in 1896 they were 24.1 per cent.

The seed from each of these plots will be planted upon the same ground in 1897 that the results may be followed up year after year.

THE EFFECT OF THE JENSEN HOT WATER TREATMENT UPON THE YIELD OF OATS.

The various experimenters who have used the hot water method* have usually recorded considerable gains in yield as a result of the treatment over and above what might be expected from simply destroying the visible smut.†

It is an important fact if true that so simple a treatment will add materially to the yield of this grain. The reason for this supposed gain has remained in doubt, however, being most generally attributed to the fact that the treatment aids in the development of a ferment within the seed which favors the more vigorous growth of the seedling.‡

In all cases where this gain has been reported seed was used which contained a considerable per cent. of smut. In our own experiments to determine how great is the increase from this source we have used seed practically free from smut, and each season have found a loss rather than a gain from the disinfected seed. The tests of previous years|| were repeated in 1896 with similar results. The oat field contained four acres and was laid off in a series of parallel plots, alternate plots being planted with treated and untreated seed. The treated seed was soaked for 10 minutes in water held at 132°-133° F. and allowed to dry for 24 hours before sowing. The seed on all plots was carefully weighed so as to make allowance for the swelling and similar amounts of seed were sown in all cases.

The yields were as follows:

2 acres,	untreated seed,	3600 pounds.
2 "	treated "	3393 "

The difference is not great but adds further evidence that where seed perfectly free from smut is used there is no gain and may be a loss following the hot water treatment.

Recent investigations by Bolley§ lead him to attribute the gain which he has observed to the destruction of the smut fungus which may exist in the plants and decrease the yield without appearing in the grain.

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*This consists in soaking the seed for 10 to 15 minutes in water held at a temperature of 132°-135° F. For details, see Rpt. Vt. Exp. Sta., 7 (1893), p. 61.

†See Bul. Kan. Exp. Sta. 22 (1891), p. 80. where Kellerman observed gains of from 3 to 8 bushels per acre, apparently attributable to some effects other than the destruction of the smut.

‡ See discussion by Dr. J. C. Arthur, Proc. A. A. A. S., 41 (1892), pp. 226-227.

||Rpt. Vt. Exp. Sta., 6 (1892), pp. 76-77.

§Bul. N. Dak. Exp. Sta., 27 (1897), pp. 119-120.

IV. THE ONION MILDEW.

The destructive occurrence of this mildew was noted in our last report (pp. 113-115), and its probable life-history discussed. Further observations during the spring and summer of 1896 confirmed the results obtained in 1895. The mildew again appeared where onions were sown upon infected garden soil, though owing to the weather conditions the disease was less destructive than in 1895.

1. LABORATORY STUDIES UPON THE FUNGUS.

All attempts at growing the fungus in culture failed as did also inoculation experiments. The circumstances were, however, unfavorable for this work owing to the distance of the diseased fields from the laboratories. The fungus produces two kinds of spores as was explained in our last report. Germination experiments show that the summer spores (conidia), which are produced in enormous numbers, are very short lived, so that it was impossible to get spores from leaves as ordinarily brought from the field to germinate. By placing some of the leaves in a moist chamber over night a fresh growth of the fungus was induced and spores taken directly therefrom germinated in water, each producing a single germ tube.

The fungus lives through the winter by means of resting or "winter" spores. These are thicker walled and formed in the latter part of the season. Examination of the onion leaves during the last week of August showed these spores to be then few and immature. They were much more abundant in leaves from the same field in the middle of September, showing that they are mostly formed during this month. These spores pass into the soil where the blighted onion leaves are allowed to remain in the field, as is commonly the custom, and germinating the following spring start the disease anew if onions are again planted on that soil. The fact of this soil infection was clearly shown experimentally by growing onions in our greenhouse during the winter of 1895-6. The seed was sown in December. At the same time a barrel of soil, secured the previous autumn from the surface of an onion field where the blight had occurred, was worked into the surface over one-half of the bench. In April the mildew appeared quite abundantly on this portion of the bench, but none occurred upon the other end. If pains are taken to remove all the leaves together with the bulbs from a field that has blighted it would seem quite possible to keep the soil practically free from the fungus. The leaves, of course, should be burned or otherwise destroyed. If the leaves and many bulbs are left on the ground the soil will become filled with the germs and the mildew will be certain to appear if the weather favors. Rotation of crops must then be practiced.

2. FIELD EXPERIMENTS WITH FUNGICIDES.

It seems to us that the destructive occurrence of the mildew can be largely prevented by the precautions explained above. In some cases, however, it may be impossible to prevent the recurrence of the disease, or there

may be danger of the fungus being carried by wind or insects from neighboring fields. In this case spraying is the hopeful remedial measure. In order to test the merits of various fungicides in checking the mildew a series of plots were sprayed or dusted three times with the following materials: Standard bordeaux mixture, standard bordeaux mixture and soap, potassium sulphide solution, flowers of sulphur.

Two great difficulties were met ; first, the solutions do not adhere well to the erect glaucous leaves of the onion; second, bordeaux mixture of the strength used proved quite injurious to the onion leaves. As no mildew appeared on this field the fungicidal values were undetermined. It is probable that a weaker bordeaux mixture may prove less injurious. Mr. S. A. Beach of the New York State Station informs us that onions are successfully sprayed with bordeaux mixture by some New York growers.

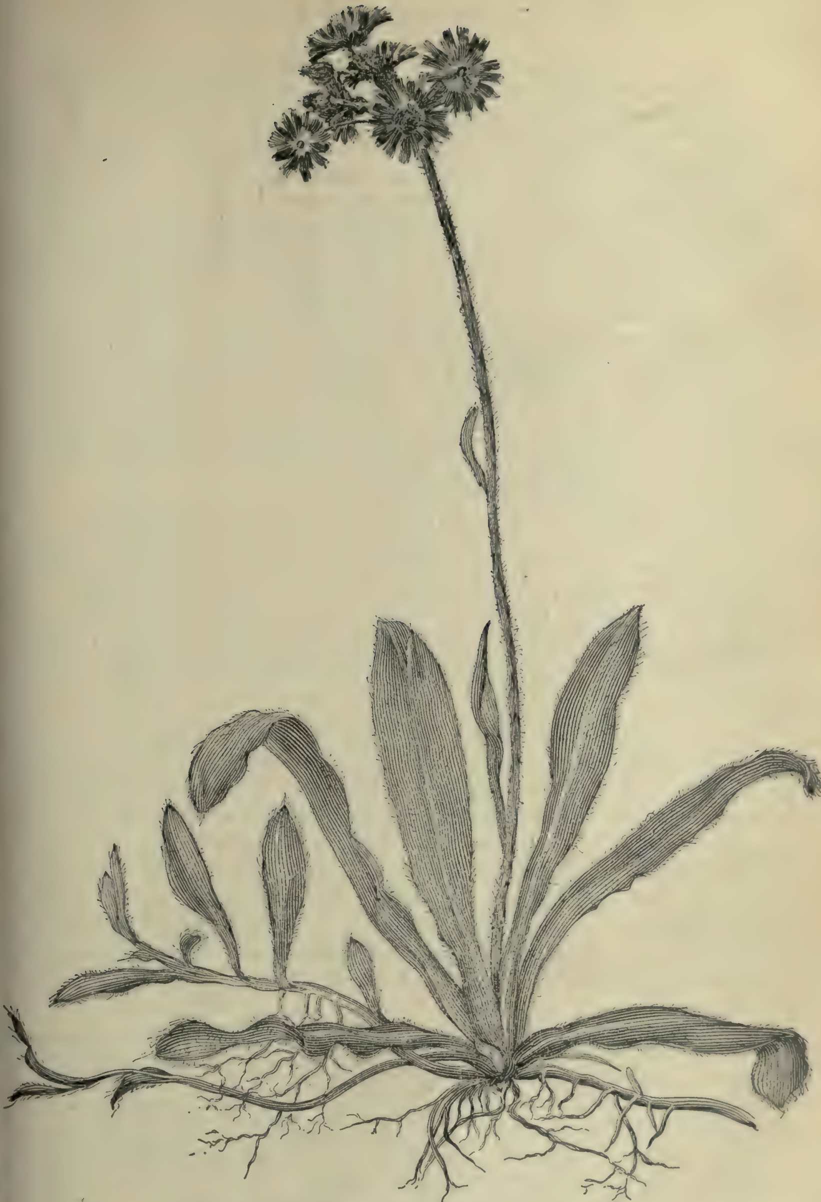
V. THE ORANGE HAWKWEED OR "PAINT-BRUSH."

During the past few years the orange hawkweed has come prominently into notice in Vermont as a dangerous weed. On account of its rapid spread, utter uselessness, and thorough monopoly of the soil, it is at the present time the worst weed known in some sections of the state, and threatens to become still more widespread. In order to prevent this so far as possible the station has made a careful study* of the plant from the economic standpoint. The practical conclusions drawn were published in bulletin form during the winter. The following account contains the substance of the matter of this bulletin, together with the more technical descriptions of the plant, details of its history and distribution, and more complete accounts of the results of experimental work upon it.

Names. The plant has been known to botanists in Europe for nearly three centuries, and naturally has received many different names. It was first termed *Hieracium fuscum* by Villars, then *Hieracium aurantiacum* by Linnæus, by which name it is still known. It is commonly called "orange hawkweed" in America, which is a literal translation of its botanical name, in Germany it is known as the *Pomeranzenfarbiges Habichtskraut* or orange colored hawkweed, while its many black hairs have led English gardeners to call it "Mr. Collier," or "Grim the Collier."

Its showy character and rapid spread as a weed have suggested several other local names such as golden hawkweed, hawkweed, paintbrush, red paintbrush, ladies' paintbrush, flora's paintbrush, devil's paintbrush, red daisy, missionary weed, lion's tongue and tassel flower. It is most widely known as "orange hawkweed" or as "paintbrush" in this state, other names being less generally met.

*Mr. W. A. Orton, a senior student in the Agricultural Department of the University, made this the subject of his thesis investigation, and had personal charge of most of the work.



1. THE ORANGE HAWKWEED OR "PAINT-BRUSH."

Entire plant in flower, one-half natural size. This plant originated from the runner shown at the lower right hand corner. The two young runners at the left have already taken root, and will soon give rise in turn to new plants.

*Description.** *Hieracium aurantiacum* L Perennial, by slender rootstocks and numerous runners. Stem simple, erect, one to two feet high, densely hirsute, the hairs towards the apex of the stem black at the base. Leaves mostly radical, oblong lanceolate, slightly denticulate, hirsute on both sides; those of the stem two or three, all but the lowest reduced to bracts. Heads 5-30, in a bracted cyme; peduncles with long, straight multicellular hairs, black glandular hairs, and a close grey covering of stellate hairs; involucre about 85 mm. in diameter, its bracts linear-lanceolate, little imbricated, provided on the back with straight, glandular, and stellate hairs. Florets 60-75, all perfect, with ligulate corollas, flame-red at the outside, shading into orange at the center. Achenes 2-2.5 mm. long, 5 mm. wide, dark brown, linear in outline, terete, ten-ribbed, rough, often slightly curved, contracted at the top, forming a little cup on which the pappus is seated. Pappus consisting of numerous grayish rough bristles, two to three times the length of the achene, arranged in a circle around the outer edge of the top of the achene, in structure like the straight hairs on the leaf. Seed conforming closely to the interior of the achene, testa strong, membranous, white; endosperm absent. Embryo comparatively large, filling the whole seed, straight, white. Cotyledons linear, obtuse, entire, closely applied face to face. Radical terete, obtuse, shorter than the cotyledons, straight.

Seedling. Primary root tapering, flexuose, with numerous lateral branches which soon take its place. Hypocotyl bent on first germinating, then erect, glabrous, light-green. Cotyledons oblong-spatulate, tapering to a broad base, without any discernible venation. Stem with the primary internodes but little developed. Leaves, first pair simple, entire, opposite, ovate-oblong, pubescent on both sides, petiolate; second pair longer, winged petioled; third leaf oblong-lanceolate, slightly denticulate, tapering to a broad, slightly sheathing base, but not petioled; subsequent leaves alternate, similar to the last.

Habit of Growth. The plant is low growing, its leaves lying close to the ground. Its roots are perennial, small, fibrous and shallow. The habit of the plant is well shown in Fig. 1. The plant propagates itself vegetatively by means of stolons or creeping stems, which start from the axils of the lower leaves, and tend to grow downward, burying themselves just under the surface of the soil and becoming rhizomes. When thus growing just under ground they are nearly leafless, and are either white or of a light reddish tint; but when forced by circumstances to grow on the surface, exposed to the light, they become quite leafy and of a dark red color. Each stolon gives rise to a plant, and as this creeping stem is perennial, the plants remain connected with each other.

The stolons are produced very abundantly, in fact, they form the principal means of propagation. A count made in August showed twenty to thirty new plants starting by stolons during that season from a single old plant, situated in a favorable location. The new plants form a dense growth, completely covering the ground, driving out everything else. On account of this mode of growth it tends to form patches in fields.

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*In part modified from Rpt. U. S. Dept. Agr., Div. Bot. (1890), p. 388.

The hawkweed is not, however, dependent on runners alone for propagation, for it produces abundant crops of fruit. It flowers the first year from seed, the first blossoms appearing in this latitude from the tenth to the sixteenth of June. The seeds mature before haying time, and become widely scattered in the hay. The same plant may flower and fruit several times in one season, so that a field of the weed appears in almost continuous blossom from June to November, and scatters seed with every wind. A single plant may produce from 1,000 to 1,500 fruits, each provided with a pappus of long hairs to aid dispersal by the wind.

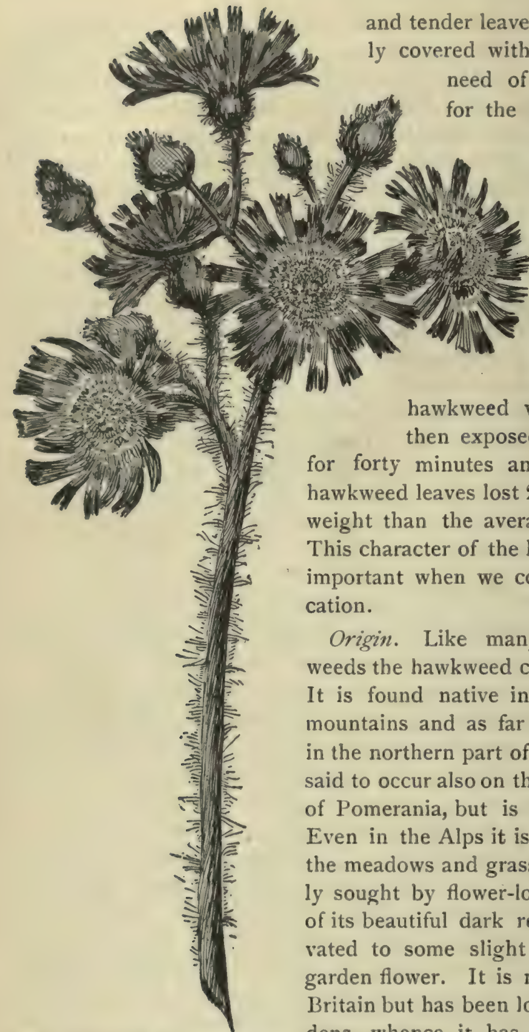
The seeds show decided viability when fresh, and a considerable proportion germinate the first season if favorable conditions are met. In ground adjoining a field of hawkweed which had been allowed to go to seed in 1896, all the vacant spaces were completely filled with the little seedlings, showing that there may be rapid spread by seeds.

Germination tests have shown that the seeds early lose their viability. The following figures show the results of recent tests at this station:

Fresh	60	per cent. germinated.
One year old	44	" "
Two years old	35	" "
Three " "	16	" "
Five " "	0	" "

These results obtained with seeds carefully kept from extremes of heat and cold suggest the probability that hawkweed seeds when exposed to the vicissitudes of winter and summer in their natural resting places are comparatively short lived. We may not expect to find several means for propagation reaching their highest development in the same species. The hawkweed has the system of propagation by stolons so highly developed that seeding is becoming a secondary method with it, as it has already become with the Canada thistle.

Structure. The structure of the hawkweed is not materially different from that of other plants of the same class. Its leaves are rather thin and the whole plant is densely hairy. The hairs are of three forms, straight, glandular, and stellate. The first form is the most prominent, being found on every part of the plant which is exposed to light. They are very long, and being filled with air are light colored. The capitate or glandular hairs are found on the stem, and on the peduncles and involucres of the flower heads. They are most numerous near the flowers. The stellate hairs are found on the under side of the leaves, on the stem and on the involucres. They consist of a stalk of four or five simple cells, with a much branched terminal cell or cells filled with air. These hairs protect the plant in several ways. (1) They tend to render the plant distasteful to animals. (2) The hairs on the stem prevent crawling insects from reaching the flowers. (3) They retard transpiration, since being filled with air they shade the epidermis, and protect it from the heat and light of the sun. This is especially the case with the young



2. CLUSTER OF FLOWERS. (Natural size.)

and tender leaves which are most densely covered with long hairs. There is need of some such protection, for the hawkweed is not otherwise adapted to withstand hot, dry conditions. It is one of the first plants to wilt from lack of water and loses water more rapidly than most other plants. Several leaves of hardy weed plants and of hawkweed were weighed carefully, then exposed to the heat of the sun for forty minutes and again weighed. The hawkweed leaves lost 20 per cent. more of their weight than the average of the other plants. This character of the hawkweed becomes very important when we come to consider its eradication.

Origin. Like many others of our worst weeds the hawkweed came to us from Europe.* It is found native in Norway, in the Alpine mountains and as far south as the mountains in the northern part of Italy and Spain. It is said to occur also on the moors of Hanover and of Pomerania, but is nowhere very common. Even in the Alps it is found but sparingly in the meadows and grass-plots, where it is eagerly sought by flower-loving tourists on account of its beautiful dark red flowers. It is cultivated to some slight extent in Europe as a garden flower. It is not indigenous in Great Britain but has been long used in cottage gardens, whence it has sparingly escaped into copses and woods in various places.

From these statements it is evident that it has not shown the characters of a serious weed in any case either in England or on the continent of Europe. It is difficult to understand why the plant is a weed in its adopted home and

*Our thanks are especially due to Professor Carruthers, of England, and Doctors Stebler, of Switzerland, and Nobbe, of Saxony, for information concerning the occurrence of the plant in Europe.

shows no such tendencies in its native habitat. Indeed, when one considers its methods of propagation, the question is not why it is a weed in the north-eastern United States but rather why does it not become a weed wherever it grows. Such occurrences are, however, not uncommon. Other cases might be cited of harmless plants becoming weeds on introduction to another climate, and not infrequently insects which cause little trouble in their native home become serious pests when brought to another country. This may be in part accounted for by the absence in the new home of those enemies, insect and fungus, which seemed to hold it in check in its native country. Moreover the changed equilibrium of the forces acting upon the plant from within and without impel it to adapt itself to its new environments and frequently to acquire greater variability and adaptability, qualities most needful for its successful existence as a weed.

The hawkweed is known to have been in America for over fifty years without appearing as a weed, during which time it may have been varying and adapting itself to its new environment.

Introduction into America. The hawkweed was brought to America as a garden flower early in the present century, the exact date of its introduction being unknown. It is first referred to as a cultivated plant in an American publication in 1818.*

No reference has been found to its exhibition of weedy tendencies prior to sometime between 1860 and 1875. Attention appears to have been called to its escape from the garden and its dangerous character as a weed for the first time in August, 1881,† by Mr. W. H. Lennon, of Brockport, N. Y. A month later Thomas Meehan writes:‡ "I have had it sent to me several times from correspondents in the Eastern States during the past 20 years," and, later,§ "Mr. Chas. J. Sprague, of Boston, found it in the summer of 1880 in St. Albans, Vt., covering large patches of bare hilltops where the grass was thin and scant and in what appeared to be old fields where it seemed to have taken full possession." Mr. C. G. Pringle, of Charlotte, Vt., states that he first saw the hawkweed outside the garden in 1873, growing by the roadside near Shelburne Falls, Vt. This is about the time it was noticed first in Rhode Island and other places. From this time on notices of its occurrence and its weedy propensities are more frequent, indicating that the hawkweed began its rapid spread in the early seventies.

The hawkweed has never been very extensively cultivated in this country and is not now catalogued by our principal seedsmen, from but one of whom could seed be obtained this year. There is no doubt, however, that hawkweed was distributed throughout New England in the seventies by seedsmen and through its use as a premium by an agricultural journal.

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*Eaton, Manual of Botany, 2nd Ed. (1818), p. 272.
†Bot. Gaz. 6 (Aug. 1881), p. 248.
‡Ibid. 6 (Sept. 1881), p. 265.
§Ibid. 7 (Jan. 1882), p. 7.

3. THE DISTRIBUTION OF THE ORANGE HAWKWEED IN VERMONT.

As reported to the Experiment Station in June, 1897. No reports received from towns not marked.

Meaning of the marks:—The circle (O) indicates that the hawkweed has not been seen; one line (|) indicates that it occurs but sparingly; two lines, (||) that it is well scattered but not yet recognized as a bad weed; three lines, (┼|) that it is well established as a weed; four lines (the double cross) that it is a very bad weed.

Letters of inquiry were sent during the summer of 1896 to leading farmers in all parts of the State asking about the occurrence of the hawkweed, time and mode of introduction, its character as a weed, rapidity of spread, soil conditions most favorable, experience in eradication, etc.

Two hundred replies were received. The plant was reported a serious weed by 122, as occuring sparingly by 35, and was not known in the locality by 40. It was stated to be spreading rapidly by 100 and to be making but slow progress by 54. Its method of introduction was stated to be as a garden flower by 40, in grass seed by 7, by wind and birds by 10 and by other means by 5. The distribution of the hawkweed in Vermont as learned from these inquiries is indicated by the map on the opposite page.

It is most troublesome in the northwestern portion of the state. Franklin, Grand Isle, Lamoille, Orleans and Chittenden counties are thoroughly infested with it, and it is widely introduced in the remaining portions of the state, though in many cases not as yet recognized as a serious weed. The spread of the weed into parts of the state where it is not now known is probably only a question of time.

Outside of Vermont the hawkweed occurs as a dangerous weed in Maine, New York, Northern Pennsylvania and Eastern Quebec, and is known to occur, though not as yet troublesome as a weed, in New Hampshire, Massachusetts, Rhode Island, Connecticut, New Jersey, Eastern Pennsylvania, Ashtabula county, Ohio, and Michigan.

In its spread in Vermont as well as elsewhere it has shown a preference for a cool climate and the higher altitudes, conditions similar to those of its home in the mountains of Europe; but as already suggested it seems to be in a measure changing these tendencies. It has been reported as thriving in all soils and almost all locations from sandy fields to the heaviest undrained clay, and from the rocky sides of the Green Mountains to the fertile shores of Lake Champlain. No soil is too poor and none too rich for its successful invasion.

Reports like the following are numerous: "My farm is now one complete mass of the weed. It was first brought there in 1886 or 1887 as a flower, and spread in spite of all effort to check it, until today it has nearly ruined the whole locality." "It will soon drive everything out of some pastures in this town if it is not checked." "It is spreading rapidly, and completely runs out all grass." "Some pieces of land are ruined by the wild carrot, but I think the paintbrush will beat them all if it is not kept down." Many more statements might be cited which place the hawkweed first in the list of bad weeds in Northern Vermont. Such reports come, however, largely from farmers having hill pastures or meadows which do not admit of thorough cultivation. This weed ought never to prove very troublesome in tillable land where the soil can be kept fertile and short rotations practiced. But in the lawns and roadsides, in neglected fields and hill pastures, where it can have plenty of time to establish itself, and where cultivation cannot be practiced it is proving to be the worst weed which has as yet invaded Vermont.

Eradication. It seems scarcely necessary to say that where this weed is not already present precautions should be taken to prevent its introduction. Hay and manure from infested lands should be avoided. If it is allowed to establish itself by roadsides and in waste places, it will soon spread to the neighboring fields. Such plants should not be allowed to form seeds in any case, and as far as possible should be eradicated. The first and most important means of fighting any weed where it is possible to practice it is

Cultivation. It is obvious that a plant with runners and rootstocks like the hawkweed cannot be combated by hand pulling. Such attempts leave numerous rootstocks in the soil and will at best give the weed but a temporary set back. For the same reason cutting off the plants with a hoe is not likely to be successful unless followed up repeatedly.

4. THE HAWKWEED IN FRUIT.
Three hundred seeds ready to sail away on the next breeze.

The hawkweed readily yields to careful plowing followed by thorough cultivation. We have found by experiment that it is possible practically to exterminate the plant in one year in this way. In one case, late fall plowing in a dry field, followed by a little cultivation and dry weather during the following spring destroyed the weed entirely. In general practice, however, a year or two of thorough cultivation should be given to insure the best results.

Salt. The hawkweed is often most troublesome in places where cultivation is impossible on account of the nature of the ground. Cultivation is undesirable, moreover, when the weed exists in small patches. A very effective remedy is found for such cases in *salt*. This agent has long been used in fighting weeds but in most cases such heavy applications are required as to destroy the grass and other useful plants along with the weeds.

The hawkweed, however, is peculiarly sensitive to the action of salt. It is quickly killed by an application which leaves the grass uninjured or sometimes even benefited.

Adjoining plots were staked out in a field badly infested with the weed and dry salt was sown broadcast at the rates respectively of 2,000, 3,000, 5,000, and 10,000 pounds per acre. The heaviest application entirely destroyed both hawkweed and grass. *All of the lighter applications proved ultimately beneficial to the grass* and in varying degree destructive to the weed. Most of the weed was killed by the application of a ton to the acre and *it was entirely killed when a ton and a half to the acre was used.* These applications were made May first. Two months later the grass (meadow fescue) upon the salted plots was noticeably larger and of a richer darker green than was that on the adjoining soil where no salt had been applied. Ten plants of the grass from the unsalted plot weighed 14 grams while ten from the salted plot weighed 26 grams or nearly twice as much. (See Fig. 5, p. 72). It was noticeable, moreover, that the grass grew more rankly during the following season on the salted area.

Repeated trials have proved that where the weed is thoroughly established so as to cover the entire ground 18 pounds of salt per square rod or 3,000 pounds per acre is sufficient to destroy every plant of the hawkweed. In all cases upon our soil such applications of salt benefited grass in the end but injured or killed clover. White clover was injured much more than red clover. When the weeds are scattered much less salt will suffice. If but a few plants occur a small handful of salt scattered over the leaves will prove sufficient.

It should not be inferred that similar applications of salt will prove equally beneficial by doubling the grass yield on all soils and under all circumstances. Salt acts as a fertilizer on land, not because of any plant food it contains, but,among other reasons,because it may so act on the insoluble elements already in the soil as to render them more soluble and hence more readily available to the plant. Salt will therefore prove more beneficial on some soils than on others. It seems probable from our experiments, however, that this weed may be destroyed in any soil by applications of salt in amounts which will be more likely to prove beneficial than injurious to the grass. Salt was applied at the rate of 3,000 pounds per acre to one field completely filled with the hawkweed and soon after the land was plowed and seeded to grass. The salt destroyed practically all the weed and appeared in no way injurious to the new seeding, the stand of grass this season being quite as good on the salted ground as on that adjoining which was not salted.

Two questions naturally arise at this point, first, what is the explanation of the action of the salt in killing the hawkweed ? and, second, why is it more susceptible to this destructive action than are other plants ? Unquestionably the chief if not the entire cause of the fatal action of the

5. THE RELATIVE EFFECTS OF SALT AND OF HAWKWEED ON GRASS.

The cluster at the right grew in the midst of hawkweed; that at the left was similarly situated except that 3,000 pounds per acre of salt had been applied, the result being the entire destruction of the weed and the doubling in weight of the grass.

salt, is to be found in its activity in withdrawing the water from the plant. When dry salt is sprinkled upon hawkweed foliage it soon draws enough water from it to dissolve the salt, and the leaves wilt and ultimately die.

This explanation is in accord with the important practical fact that *salt is more destructive to this weed when applied during hot, dry weather than when used during wet weather ;* moreover, the *dry salt kills the weed quicker than brine.* Brine applied at the same rate as dry salt, (3,000 pounds per acre) to ground filled with hawkweed was found to give the plants a set back, because the leaves were killed, but new foliage was rapidly developed and the plants grew as thickly as before the application.

The cheaper coarse "agricultural salt" has proved quite as effective as the finer table salt in our experiments, and is of course recommended for use. Such salt costs in Vermont from $3.50 to $5.50 per ton, rendering its use in fighting the weed entirely practicable.

It is interesting to note that some of the more soluble chemicals used in the manufacture of commercial fertilizers may be used to kill this weed in the same way as salt, though none are so active in this respect. Kainit, muriate of potash, sulphate of potash, and nitrate of soda have proved most effective in our experiments. The amounts required, however, involve an expense too great to make their use wise under most circumstances. Other chemicals, notably sulphuric acid and carbolic acid, kill the weed quickly, but their greater cost and poisonous nature render their use undesirable as compared with that of salt. Kerosene proved inferior to salt.

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REPORT OF THE BOTANISTS.

L. R. JONES AND W. A. ORTON.

It has been the policy of the botanical department since its beginning to make the study of plant diseases and their remedies its chief work, and to hold other problems as of secondary importance. This policy has prevailed during the past year. The larger portion of these plant diseases are caused by the attacks of parasitic fungi. An acquaintance with all species of such fungi occurring in the state is therefore of fundamental importance, and a large share of the work of the year is represented by the list of these fungi embodied in this report. This list is based upon collections accumulated during eight years, but which have been largely increased and entirely re-examined during the past year.

The work upon potato and orchard diseases is in continuation of that of former years. Further observations and experiments have been made upon agricultural grasses. Work upon weeds has demanded more attention than heretofore, including the study of their habits and occurrence in Vermont, means of introduction, dissemination and eradication. A beginning has been made upon the study of an interesting problem, namely, the causes and conditions of maple sap flow.

Investigations of clover seed impurities and of sap flow in the maple were made under the direction of the writers by Messrs. L. W. Barton and W. J. Morse, as subjects for graduation theses. Much of whatever value attaches thereunto is due to their painstaking work.

It is not deemed wise to make a full report of the status of the work in all these lines. So much as is included may be grouped under the following heads:

I. Potato Diseases and their Remedies.
    1. Potato Blights and their Prevention in 1897.
    2. Potato Scab Experiments.

II. Apple Diseases and their Remedies.
    1. Spraying for the Prevention of Apple Scab in 1897.
    2. Apple Scald.

III. Two Serious Fungus Foes Recently Reported.
    1. Asparagus Rust.
    2. Club-root of Cabbage and Turnip.

IV. A Partial List of the Parasitic Fungi of Vermont.

V. Notes on Vermont Weeds.

VI. Impurities of Vermont Clover Seed.

VII. Observations upon the Causes and Conditions of Sap-Flow in the Sugar Maple.

POTATO DISEASES AND THEIR REMEDIES.

1. POTATO BLIGHTS AND THEIR PREVENTION IN 1897.

Four forms of disease were again recognized as seriously injurious to potato foliage in 1897, namely, the two fungus diseases, early blight and late blight, arsenical poisoning from paris green, and tip-burn resulting from a complication of physiological troubles.* There were some especially interesting developments of the last trouble.

Sunlight is necessary for starch formation, and starch is essential to the formation of plant tissue. Owing to the prevalence of cloudy weather, the potato plants at the beginning of August were constitutionally weak. Two conditions now operated in combination for their speedy destruction in most of the fields under observation. One was the exhaustive drain made upon the weakly tops consequent upon the formation of tubers; the second was the frequent alternation of exceptionally bright hot days with periods of cloudy or rainy weather. As a result tip-burn developed everywhere, and the greater number of potato plants about Burlington died during August from these causes before the fungus blights developed to any great degree. The relation of this tip-burn to rankness and succulence of growth was clearly shown on certain of our plants on rather poor sandy soil. A portion of these were given a heavy application of commercial fertilizer. The result was a ranker growth and finer looking plants on these fertilized plots up to the first of August. When the trial of resistance came, however, during the next three weeks these suffered considerably more from tip-burn than did the unfertilized plants.

It is evident, therefore, that this same form of trouble which we term tip-burn may result from various and quite different unfavorable conditions, especially if these occur at about the time of rapid tuber formation. The conditions of 1897 were peculiar and are not likely soon to be repeated.

The advantage of bordeaux mixture in preserving the general vigor of the plants, and so warding off this tip-burn, was clearly evident upon these plots. This mixture certainly lacks little of being a panacea for all ills to which the potato is heir, in Vermont at least.

There was the usual amount of arsenical poisoning from overdoses of paris green.

The fungus diseases, early and late blights, made their appearance in the latter part of the summer, but not until after the tip-burn had gotten well under way. The proportional damage from them was therefore lessened

*Tip-burn is the name given to a trouble which shows itself in the dying of the potato leaves at the tips and margins as contrasted with irregularly disposed spots and blotches. It may be due to any cause which sufficiently decreases the vigor of the plant, the most common one for the years 1894-96 having been insufficient moisture. See Vt. Exp. Sta., Bul. 49(1895), p. 98.

largely, because there were fewer plants left alive for them to work upon. The early blight fungus developed with unusual virulence in the latter part of August upon the earlier planted potatoes. This was checked to some degree but not entirely by bordeaux mixture. The late blight fungus appeared on our experimental plots the last of August. Its spread was slower than usual, owing to the cool and dry weather of early September. Where it got under way a little earlier in August, as in certain fields under observation at Fairfax, it spread much more rapidly, and in a short time ruined the crop. In general over the state, however, the plants were so nearly dead before this fungus began its spread that there was a proportionately smaller amount of rot than usual.

Gains from spraying.—Experimental work with fungicides was carried on in two fields. In one the soil was light and sandy; in the other it was a fairly heavy clay loam.

In the former field there was no late blight nor rot, and comparatively little early blight. The gain from the use of the mixture was chiefly attributable to its effect in keeping off insects, and in increasing the general vigor of the plants. The results, however, were none the less significant:

Yield where sprayed twice with bordeaux mixture	124 bushels per acre.
Yield of unsprayed check rows	90 " "

In the second field the potatoes were a little later, and the heavier soil led to a more vigorous growth which continued into the autumn. As a result these plants suffered from both the early and the late blights, and as heretofore in our experience the bordeaux mixture offered fairly effective protection against the early blight fungus, and was an almost perfect preventive against the late blight and rot. The results as shown by yields in bushels of tubers of marketable size per acre were as follows:

	Sound	Rotten
Sprayed 3 times with bordeaux mixture	151	11
Not sprayed	80	35

These results require no comment. They simply re-emphasize the fact that the use of bordeaux mixture upon potatoes brings a large return. The following table summarizes some of our results for the past seven years; it is becoming an old story, yet requires repeating, since so many, even of the larger potato growers, neglect to spray.

SUMMARY OF RESULTS OF SEVEN YEARS' USE OF BORDEAUX MIXTURE

Variety	Planted	Sprayed	Yield where sprayed	Yield where not sprayed
White Star	1891	August 26, September 8	313 bushels	248 bushels
" "	May 20, 1892	July 30, August 13, 25	291 "	99 "
" "	May 20, 1893	August 1, 16, 29	338 "	114 "
" "	Apr. 26, 1894	June 16, July 17, August 30	323 "	251 "
" "	May 20, 1895	July 25, August 13, 31	389 "	219 "
Polaris	May 15, 1896	August 7, 21	325 "	257 "
"	June 1, 1897	July 27, August 17, 28	151 "	80 "
Averages for seven years			304 bushels	181 bushels

2. POTATO SCAB EXPERIMENTS.

The results of numerous trials at various experiment stations since 1890 have shown beyond question that disinfection of the seed tubers is a simple, cheap, and effective remedy for potato scab and the practice of disinfection is each year becoming more general among potato growers. The disinfecting solution first recommended by Bolley* of the North Dakota station and which has been most generally used, consists of 2¼ ounces of corrosive sublimate in 15 gallons of water. More recently Arthur† of the Indiana station has recommended formaldehyde (8 oz. of commercial formalin in 15 gallons of water) as a substitute for Bolley's corrosive sublimate solution.

In many ways formalin solution is superior to corrosive sublimate, and in our judgment its use is to be preferred, provided it proves as effective as has the corrosive sublimate in preventing the scab. The chief points in its favor are as follows:

1. Formalin is non-poisonous, or nearly so, to animals, and its use is therefore attended with no danger to the life of man or stock, whereas the corrosive sublimate is one of the most deadly of poisons.

2. Formalin is a solution, and hence very readily diluted for use, whereas the corrosive sublimate is a solid and dissolves with difficulty.

3. Formalin has no injurious effect upon the seed tubers, whereas corrosive sublimate solution frequently retards the growth of the young plants to a marked degree.

THE EFFECT OF DISINFECTANTS UPON THE GROWTH OF SEED POTATOES.

In 1896 and 1897.—The retarding effect of corrosive sublimate upon the early growth from the treated seed tubers was discussed in our last report.‡

* N. D. Exp. Sta., Bul. 4 (1891)
† Ind. Exp. Sta., Bul. 65 (1897.)
‡Vt. Exp. Sta., Rpt. 10 (1896–97), p. 53.

The experiments of the two seasons, 1896 and 1897, there cited were summarized as follows:

1. Disinfecting with corrosive sublimate just before planting retarded the early growth of the plants both seasons.

2. Similar disinfection performed from one and one-half to three months before planting had no such effect.

3. Disinfecting with formalin had no retarding effect, but apparently slightly stimulated growth.

The observations of another year have served to strengthen these convictions, as is shown in the next paragraph.

In 1898.—Two varieties of potatoes were used in 1898, Early Ohio, which were slightly scabby, planted April 29, and Downing, which were quite scabby planted May 9. Each variety of seed was divided into three lots. Of these one lot was disinfected with corrosive sublimate solution (soaked $1\frac{1}{2}$ hours in a solution of $2\frac{1}{4}$ oz. corrosive sublimate in 15 gals. water); the second lot was disinfected with formalin (soaked 2 hours in a solution of 8 oz. formalin in 15 gals. of water); the third lot was left untreated to serve as a check on these. The seed was all in good condition and the disinfection was performed a few hours before planting. The relative germination was noted on each May 25th, May 28th, June 3 and July 8, with the following results.

EARLY OHIO POTATOES, PLANTED APRIL 29

Treatment of seed	Per cents of germination			
	May 25	May 28	June 3	July 8
Corrosive sublimate.....	17	44	88	100
Formalin.................	49	76	98	100
Untreated................	54	86	100	100

DOWNING, PLANTED MAY 9

Treatment of seed	Per cents of germination		
	May 28	June 3	July 8
Corrosive sublimate......................	0	23	100
Formalin............	0	73	100
Untreated	0	54	100

RELATIVE VALUES OF FORMALIN AND OF CORROSIVE SUBLIMATE IN PREVENTING SCAB IN 1897.

Experiments were undertaken in 1897 to test the relative values of formalin and of corrosive sublimate solutions in preventing scab.

Two varieties of potatoes were chosen for the work, the seed in both cases being rather scabby. Scab spots occurred on all the tubers, but were not numerous enough to prevent them from starting a good growth of plants. The plots were located on a recently cleared wood lot, now plowed for the first time, so that the soil was presumably free from the scab germs. The soil was quite sandy.

Three plots were planted May 20, each 30 feet long and containing 5 rows. One of these plots was planted with the seed treated with the corrosive sublimate, a second with that soaked in formalin, and the third with the untreated seed. These plots were somewhat separated from each other, and precautions were taken in cultivation to prevent cross-contamination. The seed was disinfected in the manner already mentioned.

The differences in germination were discussed in detail in our last report,* and the conclusions therefrom, which were favorable to the formalin, have been referred to earlier in this article.

Owing to a mistake on the part of a farm hand an application of paris green upon the formalin plot was omitted on July 27 when the other plants were poisoned, and the beetles destroyed some of the plants before the matter was noticed. The total yield from this plot was therefore somewhat reduced.

The potatoes were dug October 2 and carefully examined for scab. The results were as follows, only tubers of marketable size being enumerated:

Treatment of seed	Number of tubers free from scab	Number of tubers scabby	Per cent of scabby tubers
Corrosive sublimate..	317	42	12 (slightly scabbed)
Formalin.....	294	17	5 (" ")
Untreated	318	129	29 (badly scabbed)

No importance should be attached to the relative total yields, since for the reasons already stated the insects attacked some of the plants worse than others.

It should be emphasized, also, that the per cent of scabbiness shown by the above figures is misleading, in that none of the tubers from either of the disinfected lots showed any serious scabbing, while most of those from the untreated seed were very badly scabbed.

*Vt. Exp. Sta., Rpt. 10 (1896-97), p. 54.

Conclusions.—The results so far as can be judged from small plots and a single season's work, justify the conclusion that the formalin is at least as good a disinfectant as corrosive sublimate, and apparently somewhat more efficient. This combined with its other advantages leads us to recommend its use for the disinfection of seed potatoes.

If formalin is more effective than corrosive sublimate as was apparently the case in our experiments, it may be due to its more rapid and complete penetration into the recesses of the deeper scab pits.

For the benefit of any who may wish to use this formalin we will repeat in closing directions for so doing. The seed tubers should be soaked for two hours in a solution of 8 fluid ounces of the commercial formalin (formaldehyde) in 15 gallons of water. This soaking should be done before the tubers are cut, and may be done at any time before planting, provided always that precautions are taken not to re-contaminate the tubers after their disinfection by placing them in sacks or bins which have held scabby potatoes.

Disinfection of seed potatoes involves but very little expense or trouble, and we strongly urge every potato grower in Vermont so to cleanse his seed, provided he suffers at all from scab.

APPLE DISEASES AND THEIR REMEDIES.

1. SPRAYING FOR THE PREVENTION OF APPLE SCAB IN 1897.

The orchard of Mr. Arthur H. Hill of Isle La Motte is largely made up of Fameuse apple trees and is admirably suited for experimental study. Mr. Hill has been spraying this orchard with bordeaux mixture and paris green for a number of years past and is convinced as to the value of spraying in general. It is as yet an open question with him and the other orchardists of the state as to how many applications of the mixture are desirable, and as to the relative importance of spraying at different dates. Hence the station was invited by Mr. Hill to co-operate with him in experiments designed to give information on these points.

A block of uniformly thrifty trees in the heart of this orchard was selected for the purpose. Of these, two trees were left without spraying, two were sprayed three times and the others, five times. The mixtures applied and the dates of spraying are shown in the following table. Applications number 3, 4 and 5 were made upon the trees sprayed three times, numbers 1 and 2 being omitted.

Number of application	Date	Condition of tree	Mixture used
1	Apr. 27	Buds not open	Copper sulphate solution*
2	May 18	Leaves out, flowers not	Bordeaux-paris-green mixture†
3	June 15	Blossoms fallen‡	" " " "
4	July 18		" " " "
5	Aug. 3		" " " "

*Copper sulphate solution contained 1 pound of copper sulphate in 20 gallons of water.

†Sixty gallons of the bordeaux-paris-green mixture contained 6 pounds copper sulphate, 4 pounds lime, 1-3 pound paris green.

‡Mr. Hill intended to spray about a week earlier, but was prevented by continuous rains.

The results were most striking. Owing to the peculiar climatic conditions of the summer, the scab fungus was unusually destructive upon both the leaves and the fruit of those trees not fully protected. In the latter part of the summer it was practically impossible to find a single leaf or apple upon the unsprayed trees which was not blotched by the scab fungus, whereas the trees sprayed most thoroughly were almost entirely free from the disease.

Mr. Hill went through the orchard in September and picked up all the fallen fruit. There was a considerably larger proportion of windfalls under the unsprayed trees than under those which had been sprayed, but no measurements of these were made. It was quite evident, however, that the spraying had increased the general vigor of the trees, as well as protected the fruit. The final picking was made October 6 and 7, when the fruit on the ground and that on the trees was carefully sorted and measured. The average yields per tree were as follows:

SPRAYED 5 TIMES.

Total amount of fruit on the tree at time of harvest, 7½ bushels (60 per cent.)
" " " " ground..............5 " (40 per cent.)

SPRAYED 3 TIMES.

Total amount of fruit on the tree... ....4½ bushels (51 per cent.)
" " " " ground..............4¼ " (49 per cent.)

CHECK, NOT SPRAYED.

Total amount of fruit on the tree.................3¾ bushels (33 per cent.)
" " " " ground. ....7½ " (67 per cent.)

This fruit was sorted for market with the following results per tree:

SPRAYING OUTFIT OF MR. T. L. KINNEY, OF SO.HERO, DESIGNED FOR USE IN A LARGE ORCHARD.

On the ground (3 barrels.) On the tree (1 1-2 barrels.)

TREE I. NOT SPRAYED.

Tree I was not sprayed. The weather of 1897 was unusually favorable to the development of the scab fungus and as a result both fruit and foliage were badly diseased, and two-thirds of the fruit fell from the trees before picking time. The above illustration shows total yield, as found on the ground and on the tree respectively at the time of harvest. Compare with Tree II below; the quality of the fruit on this tree is shown upon the opposite page.

On the ground (2 barrels.) On the tree (3 barrels.)

TREE II. SPRAYED.

Tree II was sprayed 5 times with bordeaux-paris-green mixture. The fruit and foliage were thus kept almost perfectly healthy. As a result the fruit clung to the tree much better, as is shown by comparison with Tree I above. The fine quality of the fruit is shown upon the opposite page.

TOTAL YIELDS, UNSORTED, FROM TWO FAMEUSE APPLE TREES. SHOWING BENEFITS FROM SPRAYING IN CAUSING THE FRUIT TO CLING LONGER TO THE TREE. (ORCHARD OF A. H. HILL, ISLE LA MOTTE.)

No. 1 (5 apples.)
Cider apples (over 4 barrels.) No. 2 (1-2 bushel.)

TREE I. NOT SPRAYED.

Every apple on this tree was spotted by the scab fungus and many of them were deformed and cracked. Even the 5 apples classed as No. 1 were scabby. The total value of this fruit was $2.15.

See further statements upon the opposite page.

No. 2: 1 1-2 barrels. Selects: 2 barrels.
No, 1: 1 barrel.

TREE II. SPRAYED.

Scarcely a scab spot was found in the entire lot. The No. 2 fruit was so classified chiefly because of smaller size or of bruised spots. The total value of this fruit was $15.44.

THE SAME FRUIT AS SHOWN UPON THE OPPOSITE PAGE, BUT HERE SORTED FOR MARKET. SHOWING BENEFICIAL EFFECTS OF SPRAYING UPON THE QUALITY OF THE FRUIT. (ORCHARD OF A. H. HILL, ISLE LA MOTTE.)

See detailed account of the experiment on pages 195-98.

The above outfit is designed to set on a two-wheeled cart or light wagon. The large sprocket wheel can be attached to any wagon wheel, forming an efficient geared pump, operated entirely by horse power.

This shows the apparatus mounted on a two-wheeled cart as used at the experiment farm for spraying potatoes. Any ingenious man can rig up such a cart at slight expense, setting the wheels 6 feet apart so as to straddle two rows. Four rows at a time may be sprayed when the plants are small, and two rows when they are full grown.

THE SPAULDING SPRAYING OUTFIT.

SPRAYED 5 TIMES.

Selects*	5	bushels	(40 per cent.)
No. 1	2½	"	(20 per cent.)
No. 2	3¾	"	(30 per cent.)
Cider apples	1¼	"	(10 per cent.)

SPRAYED 3 TIMES.

Selects	None.		
No. 1	1⅝	bushels	(19 per cent.)
No. 2	4⅝	"	(53 per cent.)
Cider apples	2½	"	(28 per cent.)

CHECK, NOT SPRAYED.

Selects	None.		
No. 1	5	apples.	
No. 2	½	bushel	(4 per cent.)
Cider apples	11	"	(96 per cent.)

FINANCIAL OUTCOME.

It was not practicable to place the fruit from the sprayed and unsprayed trees on the market by itself but Mr. Hill estimated its value on the basis of his sales as follows:

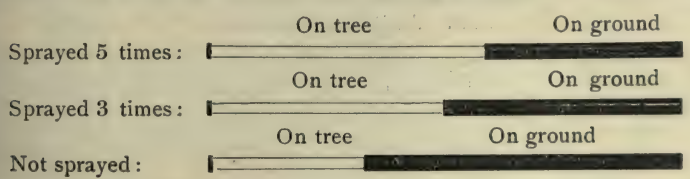
"Selects"	$1.60	per bushel
No. 1	1.40	" "
No. 2	1.00	" "
Cider apples	0.15	" "

The yields thus valued figure up as follows per tree:

Sprayed 5 times	$15.44
" 3 times	7.38
Check, not sprayed	2.15

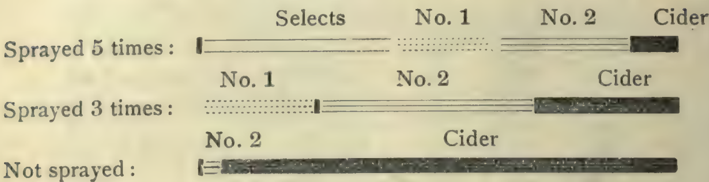
These beneficial results from spraying may be graphically expressed as follows:

BENEFITS OF SPRAYING AS SHOWN BY BETTER CLINGING OF FRUIT TO TREES.

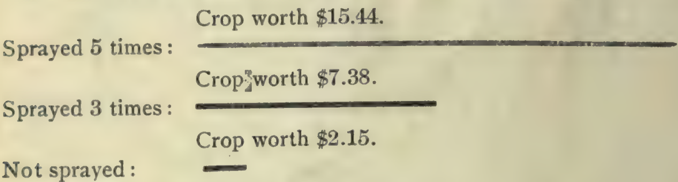


*"Selects" represented fancy fruit, every apple being practically perfect.

BENEFITS OF SPRAYING AS SHOWN BY SORTING OF FRUIT.



BENEFITS FROM SPRAYING AS SHOWN BY THE FINANCIAL RETURNS.



Conclusions.—These results need little comment. Spraying meant practically the difference between a very profitable crop and total failure the past year. It meant more than this, however. The fruit buds of 1898 were formed in 1897, and much of the starchy food which was to support these buds was then deposited. The fruit crop of 1898 is therefore largely controlled by the condition of the foliage in 1897. Even with healthy foliage the weather conditions of 1897 were not very favorable for this preparation of the trees for the 1898 crop. The enormous development of the scab fungus upon the leaves of the unsprayed trees in 1897 is, therefore, bound to shorten seriously the prospective crop of 1898, and the spraying of 1897 not only benefitted the crop of that year but also that of years to come. In other words, the results of spraying an apple tree are cumulative from year to year, the tree which is properly protected this season being ready to make a stronger growth and produce a better crop in the next one.

The importance of the first and second applications is clearly demonstrated. It is not equally clear that the fourth and fifth applications were profitable, but they probably were, under the conditions of weather of 1897. Previous experiments have shown that in a dry season three or four applications are sufficient,* the later ones being omitted.

2. APPLE-SCALD.

The attention of the experiment station was directed to the scald of apples in 1896-7, when it was unusually troublesome on Rhode Island Greenings. The results of the observations of that year are recorded in our last report.† The opinions of orchardists as there summarized are divided

*Vt. Exp. Sta., Bul. 44 (1894), p. 87.
†Vt. Exp. Sta., Rpt. 10 (1896-7), p. 55.

regarding the causes of the scald, some holding that the fruit is prepared for scalding by orchard conditions before its harvest, and that it is doomed before it leaves the tree, while others claim that the conditions, especially of temperature, surrounding the stored fruit are primarily responsible for its scalding. Further communication with practical fruit men during the past year has revealed similar differences of opinion, the larger number being inclined to hold the temperature of the store-house chiefly responsible.

Apple-scald presents a complex problem, the solution of which needs the accumulated observations and experiments of a series of seasons. A beginning in this direction was made the past year. Visits to the cellars and store houses of various orchardists of South Hero in the winter of 1896-7 had shown a marked difference in the per cent of scalded fruit. A portion of this was attributable to differences in temperature of the store room; there was evidence, however, that some was explainable only on reference to orchard conditions.

In order to follow this last question further in 1897-8, samples of Greening apples from several of these same orchards were secured in the autumn and stored together in one cellar. Some of this fruit was taken from the orchards of men who suffered severely from scald the previous year. Moreover the cellar selected was one in which a considerable scald upon all of the Greenings had developed in the winter of 1896-7. We had hoped in planning the experiment to test also the effects of varying temperatures upon the development of the scald. As the amount of desirable fruit was quite limited, however, it was not thought wise to attempt to divide it and store at different temperatures. This other phase of the question was therefore necessarily left for future experiments.

The results obtained were entirely negative, but they are none the less significant on that account. Not a single apple in the entire lot scalded. They were carefully examined in February and in March; those which did not decay earlier were again examined in May, while some were preserved even into June. At no time, however, was a typical case of scald developed. Some of the fruit was brought in March from this storage cellar into the botanical laboratory and kept there at living-room temperature. It showed slight browning of the skin, but this discoloration developed very slowly and was not like the typical scald, which was everywhere in evidence the preceding winter.

It appears certain that the primary cause of the scald must be sought in the climatic and orchard conditions, the conditions of the store house being secondary. In other words Greenings grown and matured under favorable climatic and orchard conditions can be easily carried through the winter to the point of decay without the development of scald, whereas if grown and matured under unfavorable conditions they require the most careful regulation of temperature, and perhaps of other conditions, in the storage room if they are to be preserved for any length of time without scalding.

TWO SERIOUS FUNGUS FOES RECENTLY REPORTED.

1. ASPARAGUS RUST.

The value of asparagus as a garden vegetable is receiving wider recognition each year. The asparagus bed once established is generally thought to be a fixture for an indefinite period. One of the large market gardeners of Burlington said recently that he never rooted up his old beds unless quack-grass got in and forced him to do so. Under these circumstances it is with some apprehension that we have observed the appearance at Burlington of a new and serious disease, the asparagus rust. The fungus causing this malady has been known in Europe for a century or more. It had not been observed, however, in the eastern United States previous to 1896, when Halsted* found a serious outbreak of it in New Jersey and learned of its presence as well in southern New England, Long Island and Delaware. Its occurrence as observed in 1897 was more widespread, and all fields that were badly infested in 1896 in New Jersey, at least, were rusted even worse in 1897. At the request of Dr. Halsted we made search for it about Burlington in 1896, but found none. In 1897 it was observed in a number of Burlington gardens. In most cases it was found upon long established beds, and it seems hardly probable that its introduction here has come about within these twelve months. We are rather inclined to believe that it has been heretofore less common and probably overlooked, as its presence was not suspected. However or whenever it came, it is certainly here, and probably is also present in many other places in Vermont.

As it has proved a serious menace to asparagus growers in southern New England, all in Vermont who are interested in the welfare of these plants are urged to be on the watch for its appearance, and, if found, to take prompt measures to suppress or exterminate it. It is a matter of scientific as well as of economic interest to learn how wide-spread it already is in this state, and we should like to have all who find it report the matter promptly to us, preferably sending small specimens of rusted plants.

The following description of the appearance of the rusted plants, together with suggested remedial measures, is largely drawn from Halsted's accounts.

When an asparagus plant is fully attacked it becomes brown, assuming the appearance of early maturity. Rusted plants viewed closely show numerous blister-like pustules, or rust spots, filled with brown spores, and somewhat resembling the brown rust spots on oats. Later in the autumn darker spores are produced, giving an almost black color to the rust spots.

Still another form of spore produced in early spring in tiny, cup-like pustules, was found by Halsted on asparagus plants which were left uncut. We have not yet observed the latter form in Vermont.

*N. J. Exp. Sta., Rpt. 17 (1896), pp. 407-410.

Remedial measures.—Spraying with bordeaux mixture does some good, but has not yet proved successful enough so that we can recommend its general practice.

Burning the rusted brush is the best practical remedy. It is recommended that in small beds the rusted plants be removed and burned as soon as seen. In larger fields all the brush should be cut to the ground in the autumn and burned. It is suggested in addition that a thin coat of lime be sprinkled over the soil, and that in early spring, so far as possible, this surface soil be spaded or plowed under so as to bury any remaining spores. If any plants are observed in the early spring bearing the cup forms of the rust they should be promptly destroyed.

Two species of parasitic fungi have been found preying upon the rust spots in New Jersey, and Dr. Halsted is hopeful that these natural enemies may help in holding the rust in check.

2. CLUB-ROOT OF CABBAGE.

In August 1897 specimens of diseased cabbage plants were sent to the station from Underhill Center together with an inquiry as to the cause and remedy. It proved to be the club-root, a malady resulting from the invasion of the roots of cabbages, turnips and allied plants, by a parasitic fungus, which usually leads to the malformation and ultimate destruction of practically the entire root system. Visits to this locality have shown the trouble to be general in the immediate vicinity of Underhill Center, although at Underhill, only a few miles distant, nothing could be learned of its occurrence. Serious cases of it have since been found at Burlington and inquiries and reports received during the year have led to the conclusion that this malady occurs in many other places in the state, and that it is liable to increase rapidly. A bulletin is therefore being prepared which will deal with the disease and its prevention.

A PARTIAL LIST OF THE PARASITIC FUNGI OF VERMONT.

A large proportion of plant diseases result from the invasion of the plant by parasitic fungi, while a considerable number of those which originate in other ways are complicated by the attacks of such parasites. Each species of cultivated plants harbors several different kinds of fungi, and in some cases a large number. The same is true though to a less degree of our native wild plants. Moreover the same species of fungus in many cases attacks various kinds of plants. Often the parasite spreads from wild plants or weeds to cultivated plants. These facts make it clear that any detailed study of plant dis-

eases, even from a strictly economic standpoint, requires as a fundamental much information concerning the parasitic fungi existing in the area under consideration. Since the establishment of this department there has been a gradual accumulation of specimens, notes and observations, looking to the publication of such a list as the one which follows. The final preparation of this list has been the work of Mr. Orton, who in the course of the work added largely to the field collections and observations and critically re-examined all the previous collections.

Some explanation of the form in which the list is put may be desirable. The nomenclature follows, with some exceptions, Saccardo's Sylloge Fungorum. In the Erysipheæ Burrill's classification in Ellis and Everhart's North American Pyrenomycetes has been followed. The more important recent synonyms are printed in italics after the name of the fungus. In the Uredineae the spore stage precedes the name of the host, I. indicating the aecidium, II. the uredo, and III. the teleuto stage of the fungus. Notes of interest are then given and the locality and date of collection follow. The name of the collector is indicated by an initial: C stands for H. I. Collins, G for A. J. Grout, H for T. E. Hazen, J for L. R. Jones, O for W. A. Orton. The number following the initial refers to the numbered herbarium specimen of the fungus in question. Unless otherwise stated it is understood that the fungus occurs on the leaves of the host-plant.

It is fully recognized that there is no sharp line of distinction between parasitic fungi and those which are saprophytes. There is no attempt, therefore, to make close discriminations in this matter. A list of this nature must of necessity be incomplete. Numerous additions will undoubtedly be made in the future and it is earnestly desired to obtain additional information and specimens of new species and host plants.

PERONOSPOREAE.

BREMIA LACTUCAE Regel. (*Peronospora ganglioniformis.* (B.) DeBy.)

On Lactuca sativa, Lettuce. Occasionally destructive in greenhouses. Burl., Dec. 1891; J. 411.

On Prenanthes altissima. Common. Burl., Aug. 1890; J. 410.

CYSTOPUS BLITI (Biv.) DeBy.

On Amarantus retroflexus, Pigweed. Abundant. Burl., Aug. 1890; J. 402.

CYSTOPUS CANDIDUS (Pers.) Lev.

On Capsella Bursa-pastoris, Shepherd's Purse. Very common. Burl., Sept. 1890; J. 751. South Hero, July, 1898; Waugh, 1757.

On Brassica campestris, Wild Turnip. Burl., July, 1898; H. 1816

On Brassica nigra, Black mustard. Burl., Sept. 1890; J. 748.

On Brassica sinapistrum, Charlock. Burl., July, 1898; O. 1813.

On Dentaria diphylla. Abundant. Burl., June, 1891; C. 750.

On Lepidium intermedium, Peppergrass. Common. Burl., 1894; J. 749.

On Raphanus sativus, Radish. Neither common nor very injurious. Burl., Sept. 1891; J. 752.

On Sisymbrium officinale, Beaver, July, 1898; O. 1817.

CYSTOPUS PORTULACAE (DC.) Lev.

On leaves and stems of Portulaca oleracea, Purslane. Common. Burl., July, 1894; J. 754.

CYSTOPUS TRAGOPOGONIS (Pers.) Schroet. (*C. cubicus DeBy.*)

On Ambrosia artemisiaefolia, Ragweed. Burl., Aug. 1892; J. 756.

On Tragopogon porrifolius, Salsify. Burl., June, 1890; J. 404.

PERONOSPORA ALTA Fuckel.

On Plantago major, Plaintain. Burl., June, 1891; J. 765.

On Plantago Rugellii. Burl., July, 1898; J. and O. 1780.

PERONOSPORA EFFUSA (Grev.) Rabh.

On Chenopodium album, Pigweed. Burl., June, 1893; J. 768.

PERONOSPORA PARASITICA (Pers.) DeBy.

On Dentaria laciniata. Common. Burl., June, 1891; J. 769.

On Dentaria maxima. Burl., May, 1897; J. 783.

On Raphanus sativus, Radish. Not common. Burl., Sept., 1894; J. 1367.

PERONOSPORA SCHLEIDENI Ung.

On Allium Cepa, Onion. Apparently not common, but very destructive where occurring. Milton, Sept. 1895; J. 773.

PHYTOPHTHORA INFESTANS (Mont.) DeBy.

On Solanum tuberosum, Potato. Common and in favorable seasons very destructive, causing the familiar late blight and rot of the potato. Burl., Sept. 1890; J. 408.

PLASMOPARA HALSTEDII (Farl.) Berl. & DeToni.

On Bidens cernua. Johnson, Sept. 1893; G. 430.

PLASMOPARA OBDUCENS Schroet.

On cotyledons of Impatiens sp. Burl., May, 1891; J. 780.

PLASMOPARA PYGMAEA (Ung.) Schroet.

On Anemone nemorosa. Burl., May, 1895; J. 779.

On Anemone Virginiana. Burl., May, 1897; O. 784.

PLASMOPARA VITICOLA (Berk. & Curt.) Berl. & DeToni.

On Vitis æstivalis, Summer Grape. Snake Mt., July, 1898; O. 1782.

On Vitis Labrusca, Northern Fox Grape. Burl., July, 1897; O. 778.

On Vitis riparia, Winter Grape. Burl., July, 1897; O. 1366.

Common and destructive, causing the downy mildew of grape leaves and the brown rot of the fruit; apparently worse on some varieties than on others.

SCLEROSPORA GRAMINICOLA (Sacc.) Schroet. (*Peronospora graminicola Sacc.*)

On Setaria viridis, Bottle-grass. Not common. Burl., July, 1898; J. and O. 1818

CHYTRIDIEÆ.

SYNCHYTRIUM DECIPIENS Farl.

On Amphicarpaea monoica. Common. Burl., June, 1897; O. 1204.

ENTOMOPTHOREAE.

EMPUSA GRYLLI Fresen.

On Locusts (the insects), Melanoplus atlanis Riley. Melanoplus femur-rubrum De Geer. Trimerotropus maritima Harr.

Abundant and destructive in some seasons. Burl., Aug, 1892; J. 398.

ERYSIPHEÆ.

ERYSIPHE AGGREGATA (Pk.) Farl.

On fertile catkins of Alnus incana, Alder. Johnson, Aug. 1893; G. 368.

ERYSIPHE CICHORACEARUM DC.

On Ambrosia artemisiaefolia, Ragweed. Common. Burl., Aug. 1896; G. 787.

On Aster paniculatus. Burl. Oct. 1897; O. 796.

On Aster puniceus. Newfane, Sept. 1892; G. 795.

On Chelone glabra, Turtlehead. Beaver, Sept. 1897; O. 790.

On Cucumis sativus, Cucumber. Injurious in the greenhouse. Burl., July, 1894; G. 1368.

On Hedeoma pulegioides, American Pennyroyal. Beaver, Sept. 1897; O. 791.

On Helianthus divaricatus, Sunflower. Burl., Sept. 1897; O. 799.

On Helianthus laetiflorus. Charlotte, Sept. 1897; O. 798.

On Helianthus tuberosus, Jerusalem Artichoke. Newfane, Aug. 1892; G. 800. Burl., Aug. 1898; O. 1910.

On Solidago Canadensis, Golden Rod. Burl., Sept. 1897; O. 794. Beaver, Sept. 1897; O. 793.

On Verbena hastata, Blue Vervain. Beaver, Sept. 1897; O. 788.

On Verbena urticæfolia, White Vervain. Burl., Sept. 1897; O. 789.

Cicinobolus Cesatii DeBy. frequently occurs parasitic on this fungus on various hosts.

ERYSIPHE COMMUNIS (Wallr.) Fr.

On Amphicarpæa monoica. Burl., 1890; J. 801.

On Aquilegia vulgaris, Columbine. In Herb. A. J. Grout.

On Clematis Virginiana, Virgin's Bower. Beaver, Sept. 1897; O. 802.

On Delphinium alpinum, Larkspur. Charlotte, Sept. 1897; O. 803.

On Lupinus perennis, Lupine. Burl., Aug. 1897; O. 804.

On Oenothera biennis, Evening Primrose. Burl., Oct. 1890; C. 807.

On Pisum sativum, Pea. Burl., Oct. 1891; J. 805. No. Calais, Aug. 1898; O. 1900.

On Ranunculus acris, Buttercup. Burl., Aug. 1890; C. 810. Newfane, Aug. 1892; G. 808.

On Thalictrum dioicum, Meadow Rue. Beaver, Sept. 1897; O. 811.

On Viola blanda, Violet. Beaver, Sept. 1897; O. 812.

ERYSIPHE GRAMINIS DC.

On Agropyron repens, Witch-grass. Beaver, Sept. 1897; O. 815. Burl., May, 1898; O. 1369.

On Poa pratensis, Kentucky Blue-grass. Burl., Oct. 1890; C. 814.

On Poa serotina, Fowl Meadow-grass. Burl., June, 1898; O. 1785.

On Poa sp. Winooski, Oct. 1890; C. 813.

Very common. On witch-grass it is brownish gray and quite downy. Rather injurious.

MICROSPHÆRA ALNI (DC.) Wint.

On Alnus incana, Alder. Burl., 1891; C. 813. Winooski, Oct. 1890; C. 814.

On Betula lutea, Yellow Birch. Newfane, Sept. 1892; G. 816. Beaver, Sept. 1897; O. 817.

On Ceanothus Americanus, New Jersey Tea. Burl., Sept. 1897; O. 818.

On Cornus alternifolia, Dogwood. Newfane, Aug. 1892; G. 819. Beaver, Sept. 1897; O. 820.

On Corylus rostrata, Hazel-nut. Burl., Aug. 1897; O. 821.

On Lonicera glauca, Honeysuckle. Burl., July, 1897; O. 823. Snake Mt., July, 1898; H. 1787.

On Lonicera hirsuta. Snake Mt., July, 1898; H 1786.

On Lonicera parviflora. Charlotte, Sept. 1897; O. 824.

On Lonicera Tartarica. Burl., Sept. 1890; C. 825.

On Ostrya Virginica, Lever-wood. Newfane, Sept. 1892; G. 826.

On Platanus occidentalis, Sycamore. Townshend, Sept. 1892; G. 827.

On Syringa vulgaris, Lilac. Burl., Oct. 1892; J. 828.

On Viburnum acerifolium, Arrow-wood. Newfane, Oct. 1892; G. 831. Burl., Oct. 1897; O. 832.

On Viburnum cassinoides. Burl., Oct. 1897; O. 834. Charlotte, Sept. 1897; O. 835.

On Viburnum pubescens. Charlotte, Sept 1897; O. 836.

MICROSPHÆRA DIFFUSA C. & P.

On Desmodium Canadense, Tick-trefoil. Burl., Sept. 1891; G. 837. Vernon, Sept. 1895; G. 347.

On Desmodium Dillenii. Burl., Sept. 1891; J. 838.

On Desmodium nudiflorum. Burl., Sept. 1897; O. 839.

MICROSPHÆRA ERINEOPHILA Pk.

On "erineum" caused by a Phytoptus (mite) on leaves of Fagus ferruginea, Beech. Newfane, Oct. 1892; G. 841.

MICROSPHÆRA GROSSULARIAE (Wallr.) Lev.

On Sambucus Canadensis, Elder. Burl., Aug. 1890; C. 842. Johnson, Sept. 1893; G. 844. Beaver, Sept. 1897; O. 845.

On Sambucus racemosa. Newfane, Sept. 1892; G. 843.

MICROSPHÆRA QUERCINA (Schw.) Burrill.

On Quercus alba, White Oak. Burl., Oct. 1890; C. 847.

On Quercus bicolor, Swamp White Oak. Charlotte, Sept. 1897; O. 852.

On Quercus rubra, Red Oak. Common. Burl., Oct. 1890; C. 848. Newfane, Sept. 1892; G. 849.

MICROSPHÆRA RAVENELII Berk.

On Vicia Cracca, Vetch. Burl., Aug. 1896; G. 854.

MICROSPHÆRA RUSSELLII Clinton.

On Oxalis cymosa, Wood Sorrel. Newfane, Sept. 1892; G. 855. Burl., Aug. 1898; H. 1821. Walden, Aug. 1898; O. 1896.

MICROSPHÆRA VACCINII (Schw.) C. & P.

On Epigaea repens, Trailing Arbutus. Newfane, Oct. 1892; G. 856. Burl., May, 1895; J. 857.

On Kalmia glauca. Burl., Sept. 1896; J. 859.

PHYLLACTINIA SUFFULTA (Reb.) Sacc.

On Alnus incana, Alder. Common. Burl., Oct. 1890; G. 372.

On Betula lutea, Yellow Birch. Newfane, Sept. 1892; G. 861.

On Carpinus Caroliniana, Blue Beech. Burl., Sept. 1891; C. 862.

On Celastrus scandens, Bittersweet. Abundant. Burl., Sept. 1892; J. 863. Newfane, Oct. 1892; G. 864.

On Corylus rostrata, Hazel-nut. Burl., Oct. 1897; O. 866.

On Fagus ferruginea, Beech. Newfane, Oct. 1892; G. 867.

On Fraxinus pubescens, Red Ash. Beaver, Sept. 1897; O. 868.

On Fraxinus sp. Burl., Oct. 1890; C. 869.

On Hamamelis Virginiana, Witch Hazel. Newfane, Sept. 1892; G. 870.

On Ostrya Virginica, Lever-wood. Burl., Oct. 1890; C. 871.

On paper in plant press. Newfane, Sept. 1892; G. 872.

On Ribes Cynosbati, Gooseberry. Burl., Sept. 1897; O. 873.

On Sambucus Canadensis, Elder. Burl., Oct. 1897; O. 874.

PODOSPHAERA BIUNCINATA C. & P.

On Hamamelis Virginiana, Witch Hazel. Newfane, Oct. 1892; G. 875. Burl., Aug. 1896; G. 876.

PODOSPHAERA OXYCANTHAE (DC.) DeBy.

On Amelanchier Canadensis, Service-tree. Abundant and sometimes seriously injurious. Burl., July, 1897; O. 878. Beaver, Sept. 1897; O. 879.

On Prunus sp., Cherry. Burl., Aug. 1890; J. 371. Charlotte, July, 1898; Waugh, 1881.

On Spiraea salicifolia, Meadow-sweet. Newfane, Sept. 1892; G. 581. Beaver, Sept. 1897; O. 881.

On Spiraea tomentosa, Hardhack. Abundant. Newfane, Oct. 1892; G. 882. Beaver, Sept. 1897; O. 883.

SPHÆROTHECA CASTAGNEI Lev.

On Bidens frondosa. Beaver, Sept. 1897; O. 884. Waterbury, Aug. 1898; O. 1879.

On Erechtites hieracifolia, Fire-weed. Burl., Aug. 1898; H. 1880.

On Prenanthes altissima. Burl., Sept. 1897; O. 885.

On Solidago juncea, Golden Rod. Burl., Oct. 1897; O. 886.

On Taraxacum officinale, Dandelion. Burl., Aug. 1890; J. 888. Walden, Aug. 1898; O. 1899.

SPHÆROTHECA HUMULI (DC.) Burrill.

On Agrimonia Eupatoria. Beaver, July, 1898; O. 1819.

On Geranium maculatum, Wild Cranesbill. Burl., June, 1893; Hinsdale, 891.

On Rubus odoratus, Flowering Raspberry. Abundant. Burl., Oct. 1890; C. 890. Beaver, July, 1898; O. 1820.

SPHÆROTHECA MALI (Duby.) Burrill.

On twigs of Pyrus Malus, Apple. Newfane, Oct. 1895; G. 894.

SPHÆROTHECA MORS-UVÆ (Schw.) B. & C.

On leaves and young shoots of Ribes sp., Gooseberry. Destructive. Burl., June, 1897; O. 742.

SPHÆROTHECA PANNOSA (Wallr.) Lev.

On Rosa humilis, Wild Rose. Burl., June, 1897; O. 896.

On Rosa rugosa. Charlotte, Sept. 1897; O. 897. Frequently quite injurious.

SPHÆROTHECA PRUINOSA C. & P.

On Rhus copallina, Dwarf Sumach, infested by mites. Vernon, Sept. 1895; G. 355.

UNCINULA CIRCINATA C. & P.

On Acer rubrum, Red Maple. Abundant. Sept. 1889; C. 898. Newfane, Oct. 1892; G. 899. Beaver, Sept. 1897; O. 901.

On Acer saccharinum, Sugar Maple. Newfane, Oct. 1892; G. 902.

On Acer spicatum, Mountain Maple. Burl., Oct. 1897; O. 904. Beaver, Sept. 1897; O. 903.

On Quercus alba, White Oak. Burl., Oct. 1890; C. 906.

UNCINULA CLINTONII Pk.

On Tilia Americana, Basswood. Burl., Sept. 1891; C. 907. Winooski, Sept. 1897; O. 910. Newfane, Sept. 1892; G. 908 Beaver, Sept. 1897; O. 909.

UNCINULA FLEXUOSA C. & P.

On Aesculus Hippocastanum, Horse Chestnut. Burl., Oct. 1890; J. 911.

UNCINULA MACROSPORA Pk.

On Ulmus Americana, Elm. Dummerston, Sept. 1895; G. 359.

UNCINULA NECATOR (Schw.) Burrill. (*U. spiralis*) (*U. ampelopsidis.*)

On Ampelopsis quinquefolia, Virginia Creeper. Abundant. Burl., Aug. 1890; J. 912. Charlotte, Sept. 1897; O. 913.

On Vitis sp., Grape. Pittsford, Sept. 1890; J. 361. Burl., Oct. 1890; J. 362. Newfane, Oct. 1892; G. 914.

Common, but not seriously injurious to the grape in this state.

UNCINULA SALICIS (DC.) Wint.

On Populus balsamifera, Balsam Poplar. Burl., Aug. 1890; J. 915.

On Populus tremuloides, American Aspen. Newfane, Aug. 1892; G. 917.

On Salix alba var. vitellina, Yellow Willow. Charlotte, Aug. 1897; O. 918.

On Salix cordata, Willow. Burl., Oct. 1897; O. 919.

On Salix discolor. Burl., Oct. 1897; O. 920.

On Salix humilis. Burl., July, 1897; Flynn, 921.

On Salix myrtilloides. Charlotte, Sept. 1897; O. 922.

On Salix sp. Wardsboro, Sept. 1892; G. 923. Newfane, Sept. 1892; G. 596.

USTILAGINEAE.

DOASSANSIA OCCULTA var. FARWELLII Setchell.

On fruits of Potamogeton Pennsylvanicus. Townshend. In Herb. A. J. Grout.

SPHACELOTHECA HYDROPIPERIS (Schum.) DeBy.

In ovaries of Polygonum sagittatum. Burl., Oct. 1892; J. 1120. Johnson, Sept. 1893; G. 715. Newfane, Sept. 1892; G. 67. Waterbury, Aug. 1898; J. and O. 1882.

TILLETIA STRIAEFORMIS Westd.

On leaves of Calamagrostis Canadensis, Blue-joint. Newfane, July, 1894; G. 58.

UROCYSTIS AGROPYRI (Preuss.) Schroet.

On leaves of Agropyron repens, Witch-grass. Burl., June, 1891; J. 1214.

USTILAGO ANOMALA J. Kunze.

In ovaries of Polygonum dumetorum var. scandens. Beaver, Sept. 1897; O. 1121.

USTILAGO AVENÆ (Pers.) Jensen.

In ovaries of Avena sativa, Oat. Present to a greater or less degree in all oat fields. Often quite destructive, especially where western seed is used. Burl., July, 1894; J. 1122.

USTILAGO CARICIS (Pers.) Fuckel.

In ovaries of Carex sp., Sedge. Johnson, July, 1893; G. 66.

In ovaries of Carex monile. Burl., July, 1898; H. 1753.

In ovaries of Carex siccata. Burl., July, 1898; H. 1754.

In ovaries of Carex sterilis. Stratton, July, 1895; J. 1124.

In ovaries of Rhyncospora alba. Newfane, Sept. 1892; G. 68.

USTILAGO HORDEI (Pers.) Kell. & Sw.

In ovaries of Hordeum sativum, Barley. Common. Burl., Sept. 1890; C. 1125.

USTILAGO LONGISSIMA (Sow.) Tul.

On leaves of Glyceria grandis. Johnson, July, 1894; G. 714. Burl., June, 1898; J. 1372.

USTILAGO MAYDIS (DC.) Corda.

On staminate and pistillate flowers of Zea Mays, Indian Corn. Burl., Aug. 1897; O. 1203. Common but not usually abundant enough to cause serious loss.

USTILAGO NEGLECTA Niessl.

In ovaries of Setaria glauca, Foxtail. Common. Burl., 1890; J. 1128. Newfane, Aug. 1892; G. 75.

USTILAGO SEGETUM (Bull.) Dittm.

On Arrhenatherum avenaceum, Tall Oat-grass. Abundant and injurious. Burl., June, 1898; J. & O. 1397.

USTILAGO TRITICI (Pers.) Jensen.

In ovaries of Triticum vulgare, Wheat. Not common. Burl., July, 1892; J. 1129.

USTILAGO UTRICULOSA (Nees.) Tul.

In ovaries of Polygonum Pennsylvanicum, Smartweed. Vernon, Sept. 1895; G. 84.

In ovaries of Polygonum hydropiperoides. Fuorna Mt., Sept. 1893; Eggleston, 1202.

USTILAGO VIOLACEA (Pers.) Fuckel.

In ovaries Arenaria Grœnlandica, Mountain Sandwort. Mt. Mansfield, Aug. 1898; J. 1878.

UREDINEÆ.

AECIDIUM ASTERUM Schw.

On Aster cordifolius. Burl., July, 1897; O. 1216.

On Aster corymbosus. Burl., June, 1897; O. 1217.

AECIDIUM CLEMATIDIS DC.

On Clematis Virginiana, Virgin's Bower. Johnson, July, 1893; G. 1. Starksboro, June, 1895; J. 1218.

AECIDIUM COMPOSITARUM Burrill.

On Prenanthes sp. Burl., July, 1898; O. 1790.

AECIDIUM EUPHORBIÆ Gmel.

On Euphorbia Preslii. Usually accompanied by *Uromyces Euphorbiæ* C. & P. Burl., Aug. 1891; J. 1219.

Aecidium Fraxini Schw.
On Fraxinus pubescens, Red Ash. Burl., June, 1898; O. 1792.

Aecidium Gnaphaliatum Schw.
On Gnaphalium decurrens. Newfane, Aug. 1892; G. 95.

Aecidium Grossulariæ Schum.
On Ribes Cynosbati, Gooseberry. Burl., June, 1890; J. 1221.
On Ribes floridum. So. Hero, June, 1894; J. 1224.
On Ribes prostratum. Mt. Mansfield, June, 1897; O. 1225. Occasionally injurious to cultivated gooseberries.

Aecidium Houstoniatum Schw.
On Houstonia cærulea, Bluets. Johnson, June, 1895; G. 5.

Aecidium Impatientis Schw.
On Impatiens fulva, Jewel-weed. Burl., June, 1893; J. 1226.

Aecidium Peckii DeToni.
On Oenothera biennis, Evening Primrose. June, 1897; J. 1228.

Aecidium Sambuci Schw.
On Sambucus Canadensis, Elder, causing great distortion of petioles and young twigs. Burl., June, 1892; J. 1231.

Chrysomyxa Pyrolæ (DC.) Rostr. (*Uredo pyrolata.*) (*Cœoma pyrolatum.*)
II. On Pyrola rotundifolia. Abundant. Burl., May, 1890; J. 63.

Coleosporium Campanulae (Pers.) Lev.
On Campanula rapunculoides, Bell-flower. Walden, Aug. 1898; White, 1906.

Coleosporium Sonchi (Pers.) Lev. (*C. Sonchi-arvensis* (Pers.) Lev.)
II. On Aster lævis. Burl., Oct. 1897; O. 1347.
On Aster paniculatus. Beaver, Sept. 1897; O. 1348. W. Rutland, Sept. 1897; Eggleston, 1349.
On Aster macrophyllus. Burl., Aug. 1890; J. 1350.
On Aster sp. Burl., Sept. 1896; O. 1351.
On Solidago Canadensis, Golden Rod. Burl., Aug. 1898; H. 1892.
On Solidago juncea. Burl., July, 1897; O. 1352.
On Solidago puberula. Burl., July, 1897; O. 1353.
On Solidago rugosa. Burl., 1890; G. 1354. Beaver, Sept. 1897; O. 1355.
On Solidago serotina. Burl., Aug. 1898; H. 1893.
On Solidago sp. Williston, Sept. 1890; J. 1356. Abundant everywhere on various species, and sometimes injurious to cultivated asters.

Cronartium asclepiadeum (Willd.) Fr.
On Myrica asplenifolia, Sweet Fern. Burl., Aug. 1897; O. 1258.

Var. THESII Berk. (*C. Comandræ P.*)

On Comandra umbellata. Burl., Aug. 1893; G. 7.

GYMNOSPORANGIUM CLAVIPES C. & P. (*Ræstelia aurantiaca.*)

I. On fruit of Amelanchier alnifolia, June-berry. Burl., Aug. 1897; O. 1337.

I. On fruit of Amelanchier spicata. Snake Mt., July, 1898; O. 1793.

GYMNOSPORANGIUM GLOBOSUM Farl. (*Ræstelia globosa.*)

I. On Cratægus coccinea, Hawthorn. Abundant. Burl., Oct. 1891; C. 1338.

I. On Pyrus Americana, Mountain Ash. Abundant. Burl., Oct. 1890; C. 1340.

III. On Juniperus Virginiana, Red Cedar. Abundant, producing large round swellings, or "cedar apples." Burl., May, 1891; J. 1341.

GYMNOSPORANGIUM MACROPUS Link. (*Ræstelia pirata.*)

I. On Pyrus Malus, Apple. South Hero, July, 1897; Waugh, 1342.

GYMNOSPORANGIUM NIDUS-AVIS Thaxter.

I. On Amelanchier Canadensis, Service-tree. Snake Mt., July, 1898; J. and O. 1795.

III. On Juniperus Virginiana, producing distorted growth or "witches' brooms." Burl., May, 1898; O. 1371.

ROESTELIA CORNUTI forma AMELANCHIERIS Wallr.

On Amelanchier Canadensis, Service-tree. Burl., Sept. 1897; O. 1336.

MELAMPSORA FARINOSA (Pers.) Schroet. (*M. salicina Lev.*)

II. On Salix cordata, Willow. Beaver, Sept. 1897; O. 1252.

II. On Salix myrtilloides. Charlotte, May, 1896; J. 1253.

II. On Salix nigra. Burl., Sept. 1897; O. 1254.

On Salix sp. Newfane, Sept. 1890; G. 727.

MELAMPSORA POPULINA (Jacq.) Lev.

II., III. On Populus monilifera, Cotton-wood. Common. Burl., Oct. 1890; J. 1255.

On Populus tremuloides, American Aspen. Newfane, Sept. 1892; G. 126.

MELAMPSORA SCOLOPENDRII (Fuckel.) Farl.

On Onoclea sensibilis. Williston, Sept. 1895; Tracy, 1796.

On Osmunda Claytoniana. Walden, Aug. 1898; O. 1895.

On Woodwardia Virginica. Burl., Aug. 1898; O. and H. 1903.

PERIDERMIUM DECOLORANS Pk.

I. On Picea nigra, Black Spruce. Burl., July, 1896; J. 325.

PERIDERMIUM PECKII Thum.

On Tsuga Canadensis, Hemlock. Smuggler's Notch, Aug. 1898; J. 1902.

PHRAGMIDIUM FRAGARIASTRI (DC.) Schroet. (*P. Fragariae.*)

II. On Potentilla Canadensis, Cinque-foil. Burl., Aug. 1897; O. 1343.

II. On Potentilla tridentata, Snake Mt., July 1898; O. 1797.

PHRAGMIDIUM RUBI (Pers.) Wint.

II. On Rubus hispidus. Burl., Aug. 1898; O. 1905.

On Rubus odoratus, Flowering Raspberry. Johnson, Sept. 1894; G. 13.

PHRAGMIDIUM RUBI-IDAEI (DC.) Karst.

II. On Rubus strigosus, Red Raspberry. Burl., Oct. 1890; C. 1344.

II. On Rubus villosus. Burl., Aug. 1898; O. 1898.

PHRAGMIDIUM SUBCORTICIUM (Schrank) Wint. (*P. Mucronatum.*)

II. On Rosa acicularis, Wild Rose. Snake Mt., July, 1898; O. 1800.

II. On Rosa blanda. Burl., 1892; J. 1346.

II. On Rosa humilis, Snake Mt., July, 1898; O. 1799.

II., III. On Rosa sp, Newfane, Aug. 1892; G. 120.

Not uncommon and sometimes injurious.

PUCCINIA ANEMONES-VIRGINIANAE Schw.

III. On Anemone Virginiana. Vernon, July, 1895; G. 19. Snake Mt., July, 1898; O. 1801. Providence Island, June, 1898; H. and O., 1802.

PUCCINIA ANGUSTATA Pk.

On culms and leaves of Eriophorum polystachyon. Newfane, Oct., 1892; G. 145.

On Eriophorum cyperinum. Newfane, Oct. 1892; In Herb. A. J. Grout.

On Scirpus atrovirens. Burl., Aug. 1898; H. 1883.

PUCCINIA ASPARAGI DC.

III. On stems and branches of Asparagus officinalis, cultivated Asparagus. Burl., Oct. 1897; Waugh, 1260.

A comparatively new disease, very destructive in the southern states, which now occurs to a limited extent in Vermont, but which may become general later.

PUCCINIA ASTERIS Duby.

III. On Aster corymbosus. Burl., Aug. 1897; O. 1263.

III. On Aster macrophyllus. Common. Stratton, Aug. 1894; G. 20. Snake Mt., July, 1898; O. 1803

On Aster cordifolius. Newfane, In Herb. A. J. Grout.

On Aster acuminatus. Stratton, In Herb. A. J. Grout.

PUCCINIA CARICIS (Schum.) Rebent.

II. On Carex canescens var alpicola, Sedge. Mt. Mansfield, Aug. 1898; J. 1891.

II. On Carex gynandra. Burl., July, 1898; H. 1887.

II., III. On Carex pallescens. Burl , Aug. 1898; H. 1890.

III. On Carex Pennsylvanica. Burl. 1898; H. 1901.

III. On Carex rigida var Bigelovii, Mt. Mansfield. Aug. 1808; J. 1889.

II. On Carex tribuloides var Bebbii. Burl., July, 1898; H. 1888.

II., III. On Carex. sp., Sedge. Common. Burl., Aug. 1890; J. 150. Beaver, Sept. 1897; O. 1266.

II. On Cyperus strigosus. Aug., 1896; J. 1268.

On Dulichium spathaceum. Newfane, Oct., 1892; G. 151.

PUCCINIA CIRCAEAE Pers.

On Circaea alpina. Burl., Aug. 1891; J. 152. Waterbury, Aug. 1898; O. 1886.

On Circaea Lutetiana. Newfane, Sept. 1892; G. 153. Providence Island, June, 1898; J. 1804. Snake Mt., July, 1898; O. 1805.

PUCCINIA CONVOLVULI (Pers.) Cast.

III. On Convolvulus sepium, Hedge Bind-weed. Burl., Oct. 1890; C. 1269. Newfane, Oct. 1892; G. 156.

PUCCINIA CORONATA Corda. (*Aecidium Rhamni.*)

I. On Rhamnus alnifolia, Buckthorn. Burl., June, 1896; G. and J. 1270.

I. On Rhamnus cathartica. Burl., June, 1890; J. 1271.

III. On Agropyron repens, Witch-grass. Burl., Aug. 1897; O. 1273.

II., III. On Avena sativa, Oat. Burl., Aug. 1891; J. 1274.

This rust of grasses is fairly abundant but not as injurious as the common rust, *Puccinia graminis*.

PUCCINIA EPILOBII DC.

II. On Œnothera biennis, Evening Primrose. Burl., 1890; J. 1275.

PUCCINIA FUSCA Relhan.

III. On Anemone nemorosa. Burl., May, 1890; J. 141.

III. On Anemone Virginiana. Burl., May, 1897; O. 1278.

PUCCINIA GENTIANAE (Strauss) Link.

II. On Gentiana quinqueflora. Manchester. In Herb. A. J. Grout.

PUCCINIA GRAMINIS Pers. (*Aecidium Berberidis.*)

I. On Berberis vulgaris, Barberry. Common. Burl. May, 1890; J. 1280. Rupert, July, 1891; J. 165; E. Bethel, June, 1894; J. 1279.

II., III. On Agropyron repens, Witch-grass. Burl., Oct. 1892; J. 1281.

II. On Agrostis vulgaris, Red-top. Burl., July, 1898; H. 1824.

II., III. On Avena sativa, Oat. Burl., Sept. 1890; C. 1282.

III. On Dactylis glomerata, Orchard-grass. Burl., Oct. 1891; J. 1286.

II. On Festuca pratensis, Fescue. Burl., June, 1898; White, 1822.

III. On Hordeum sativum, Barley. Burl., Oct. 1890; C. 1287.

II. On Poa pratensis, Kentucky Blue-grass. Burl., July, 1898; H. 1823.

III. On Triticum vulgare, Wheat. Burl., Aug. 1891; J. 1288.

III. On Secale cereale, Rye. Burl., Aug. 1892; J. 1289.

Very common and injurious especially to cultivated oats.

PUCCINIA HIERACII (Schum.) Mart. (*P. flosculosorum.*) (*Uredo Hieracii.*)

On Cichorium Intybus, Chicory. Burl., Aug. 1898; H. 1888.

On Cnicus arvensis, Canada Thistle. Burl., Aug. 1890; J. 1291.

On Prenanthes altissima. Johnson, Sept. 1893; G. 27.

On Taraxacum officinale, Dandelion. Common. Burl., Aug. 1890; J. 26.

PUCCINIA IRIDIS (DC.) Wallr. (*Uredo Iridis DC.*)

On Iris versicolor, Blue Flag. Newfane; G. 733. Vernon, Sept. 1895; G. 42.

PUCCINIA MALVACEARUM Mont.

III. On Althea rosea, Hollyhock. Abundant and injurious. Burl., Aug. 1890; G. 1293. Woodstock, July, 1898; J. 1806.

On Malva rotundifolia, Mallow. Burl., July, 1898; H. 1825.

PUCCINIA MARIAE-WILSONI Clinton. (*Aecidium Claytoniatum.*)

III. On Claytonia Caroliniana, Spring Beauty. Burl., May, 1892; J. 1296.

I. On Claytonia Virginica. Burl., May, 1891; J. 2. Plainfield, May, 1890; J. 89.

PUCCINIA MENTHAE Pers.

On Calamintha clinopodium. Newfane, Oct. 1892; G. 184.

On Monarda sp. Stowe. In Herb. A. J. Grout.

On Pycnanthemum sp. Burl., Oct. 1890; G. 1297.

II., III. On Pycnanthemum lanceolatum. Rutland, Aug. 1897; Eggleston, 1298.

PUCCINIA PECKIANA Howe. (*Uredo caeoma nitens.*)

II. On Rubus occidentalis, Black Raspberry. Burl., June, 1891; C. 1363. III. Burl., Aug., 1896; G. 1299.

II. On Rubus strigosus, Red Raspberry. Burl., June, 1891; C. 1362.

II On Rubus villosus. Blackberry. Colchester, June, 1894; J. 1364. III. Jamaica, Sept. 1890; G. 186. Stratton, Aug. 1894; G. 30.

The uredo stage of the fungus (*Caeoma nitens*) is abundant and destructive. The teleuto stage is not so common.

PUCCINIA PIMPINELLAE (Strauss.) Link.

II., III. On Osmorrhiza brevistylis, Sweet Cicely. Johnson, July 1893; G. 1300. Shelburne, June, 1895; J. 1301.

PUCCINIA POLYGONI Pers. (*P. Polygoni-amphibii.*)

III. On Polygonum Hartwrightii. Burl., Oct. 1891; C. 1302. Vernon, Sept. 1895; G. 31.

II. On Polygonum hydropiper, Smartweed. Burl., Sept. 1897; O. 1304.

PUCCINIA PYROLAE Cooke.

III. On leaves and stems of Polygala paucifolia. Burl., Aug. 1897; O. 1305.

PUCCINIA SORGHI Schw. (*P. Maydis.*)

II., III. On Zea Mays, Indian Corn. Burl., Aug. 1890; J. 1306. Starksboro, Sept. 1890; J. 34. Common but not very injurious.

PUCCINIA SUAVEOLENS (Pers.) Rostr.

II. On Cnicus arvensis, Canada Thistle. Burl., Oct. 1890; C. 1311.

PUCCINIA TANACETI DC. (*P. Helianthi.*)

II., III. On Helianthus annuus, Sunflower. Burl., Aug. 1890; J. 1314.

On Helianthus decapetalus. Townshend, Sept. 1892; G. 584.

III. On Helianthus strumosus. Burl., Aug. 1897; O. 1316.

Common and very destructive on the various wild and cultivated sunflowers.

PUCCINIA TENUIS Burrill.

On Eupatorium ageratoides. Johnson, July, 1893; G. 37.

PUCCINIA THALICTRI Chev.

III. On Thalictrum Cornuti. Burl., July, 1894; J. 1318.

PUCCINIA TIARELLAE B. & C.

On Tiarella cordifolia. Newfane, Oct., 1892; G. 213. Burl., Aug. 1897; O. 1319. Beaver, Sept. 1897; O. 1320.

PUCCINIA VIOLAE (Schum.) DC. (*Aecidium Violae* Schum.)

I. On Viola Canadensis, Violet. Burl., June, 1897; O. 1322. Mt. Mansfield, June, 1897; O. 1323.

I. On Viola canina. Burl., May, 1895; J. 1324.

I. On Viola palmata, var. cucullata. Burl., June, 1890; J. 1325.

III. Burl., Aug.,1890; J. 1329.

I. On Viola pubescens. Common and destructive. Burl., May, 1892; J. 1327.

II. On Viola Selkirkii. Johnson, July, 1893; G. 616.

I. On Viola sp. Fairfax, May, 1890; J. 1330. III. Newfane, Oct., 1892; G. 219.

PUCCINIA VIRGAUREAE (DC.) Libert.

III. On Solidago sp, Golden Rod. Burl., June, 1897; J. 1332.

PUCCINIA XANTHII Schw.

III. On Xanthium Canadense, Cockle-bur. Burl., July, 1895; J. 1333.

PUCCINIASTRUM EPILOBII (Chaill.) Otth. (*Melampsora Epilobii.*)

II. On Epilobium adenocaulon. Burl., Aug. 1898; O. 1904.

II. On Epilobium angustifolium. Burl., Aug. 1890; J. 1360, Newfane, Sept. 1892; G. 124.

TRIPHRAGMIUM CLAVELLOSUM Berk.

On Aralia nudicaulis, Sarsaparilla. Johnson, July, 1893; G. 39.

UREDO AGRIMONIAE (DC.) Schroet. (*Caeoma Agrimoniae.*) (*Thecopsora Agrimoniae.*)

II. On Agrimonia Eupatoria. Abundant and apparently quite destructive. Burl., Sept. 1897; O. 1361. Newfane, Aug. 1892; G. 223. Snake Mt., July, 1898; O. 1810.

UREDO POLYPODII DC. (*U. filicum.*)

On Aspidium Thelypteris. Johnson, Sept. 1893; G. 40.

On Aspidium acrostichoides. Johnson, Sept. 1894; G. 41.

On Woodsia glabella. Smugglers' Notch; Hinsdale. In Herb. A. J. Grout.

UROMYCES APPENDICULATUS (Pers.) Link. (*U. Phaseoli.*)

III. On Pods of Phaseolus vulgaris, Bean. Injurious. Woodstock, Aug. 1894; J. 1232.

UROMYCES CALADII (Schw.) Farl. (*Aecidium Caladii.*)

I. On Arisæma triphyllum, Indian Turnip. Burl., June, 1891; C. 1236. II. III, Burl., Aug. 1890; J. 1237; Beaver, Sept. 1897; O. 1233. Snake Mt., July, 1898; J. 1808.

UROMYCES CARYOPHYLLINUS (Schrank) Schroet.

II., III. On Dianthus caryophyllus, Carnation. Burl., Jan. 1893; Stevens, 238. Injurious in greenhouses.

UROMYCES DACTYLIDIS Otth. (*Aecidium Ranunculacearum DC.*)

I. On Anemone Virginiana. Burl., June, 1895; J. 1229.

UROMYCES EUPHORBIÆ C. & P.

II. On Euphorbia Preslii. Burl., Aug. 1897; O. 1237.

On Euphorbia maculata. Vernon, Sept. 1895; G. 46. Burl., Aug 1898; O. 1897.

III. On Euphorbia sp. Burl., Aug. 1892; J. 1236.

UROMYCES FABÆ (Pers.) DeBy.

II. On Vicia Cracca, Vetch. Burl., Aug. 1895; J. 1238.

UROMYCES GERANII (DC.) Otth. & Wartm. (*Aecidium Geranii.*)

I. On Geranium maculatum. So. Hero, June, 1894; J. 1239.

UROMYCES HEDYSARI-PANICULATI (Schw.) Farl.

III. On Desmodium Dillenii, Tick-trefoil. Burl., Oct. 1890; C. 1240.

UROMYCES HYPERICI (Schw.) Curt.

I., II., III. On leaves and stems of Hypericum Canadense var. majus, St. Johnswort. Newfane, Aug. 1892; G. 248. Beaver, Sept. 1897; O. 1243.

III. On leaves and stems of Hypericum mutilum. Newfane, Aug. 1892; G. 247. Brattleboro, July, 1895; J. 1242.

UROMYCES JUNCI (Desm.) Tul.

On stems of Juncus sp. Burl., Mar. 1893; J. 324.

UROMYCES LESPEDEZÆ (Schw.) Pk.

I., II. On Lespedeza capitata. Burl., Aug. 1891; J. 1244. Guilford, Oct. 1892; G. 251.

UROMYCES LILLII Clinton.

III. On Lilium candidum, Lily. Charlotte, June, 1896; J. 1246.

UROMYCES POLYGONI, (Pers.) Fuckel.

II. On Polygonum aviculare, Knot-weed. Waterbury, Aug. 1898; O. 1885.

UROMYCES PYRIFORMIS Cooke.

On Acorus calamus, Sweet Flag. Burl., Sept. 1896; G. 1247.

UROMYCES RHYNCOSPORÆ Ell. & Gall.

On Rhyncospora alba. Newfane; In Herb. A. J. Grout.

UROMYCES TEREBINTHII (DC.) Wint.

II., III. On Rhus Toxicodendron, Poison Ivy. Abundant and destructive. Burl., July, 1897; O. 1248. Snake Mt., July, 1898; O. 1809.

UROMYCES TRIFOLII (Hedw.) Wint.

III. On Trifolium hybridum, Alsike Clover. Burl., Sept. 1890; C. 1250. Charlotte, Aug. 1897; O. 1251.

III. On Trifolium pratense, Red Clover. Common and injurious. Burl., Oct. 1890; J. 259.

I., II. On Trifolium repens, White Clover. Burl., July, 1898; H. 1821.

NOTES UPON VERMONT WEEDS.

In connection with the work upon the orange hawkweed during the past two years, many reports concerning other weed plants have been received. In addition to these a large number of the readers of bulletin 56 answered the inquiries regarding weed plants there appended. It is planned in the near future to issue a bulletin on Vermont weeds, discussing occurrence, distribution and modes of controlling. It seems best at the present time, therefore, to give merely a tabulated summary of these reports, together with some illustrations and brief remarks upon those of especial interest, one of the chief objects being to secure further information upon the occurrence of new weeds and also the results of successful experience in the eradication of old offenders. Specimens of new or unknown plants will be received and identified with pleasure if sent to the experiment station.

In the circular of inquiry referred to above was the question: "What five weeds are proving most troublesome in your vicinity?" Some 200 replies were received from all parts of the state. Local popular names were frequently used in the replies, and in the case of some groups of closely related plants it was impossible to determine which species was referred to. In most such cases, however, the behavior of the different species as weeds is so similar that this obscurity is a matter of little practical moment. A summary of these replies follows. The figures given after each name indicate the per cent of all the reports which included this weed as one of the worst five weeds for that vicinity. In parenthesis is given for each plant the list of the various popular or local names under which it has been reported to us from Vermont. We shall be glad to learn of other popular names in local use.

1. THE DOZEN WEEDS MOST FREQUENTLY REPORTED.

WHITE DAISY. *Chrysanthemum leucanthemum.* 80 per cent.
(Ox-eye Daisy.)

KALE. *Brassica sp.* 73 per cent.
(Wild Mustard, Charlock, Cadlack.)

This name is applied indiscriminately to the four species of Brassica which occur in Vermont, *B. nigra*, or Black Mustard, *B. campestris*, or Wild Turnip, *B. Sinapistrum* or Charlock and *B. juncea*, or Indian Mustard.

ORANGE HAWKWEED. *Hieracium aurantiacum.* 46 per cent.
(Hawkweed, Paintbrush.)

For details of occurrence, etc., see bulletin 56, or tenth report.

WILD CARROT. *Daucus carota.* 33 per cent.
(Wild Caraway, Wild Parsnip.)

This is simply the garden carrot run wild. It is one of the worst of hayfield weeds, and may be readily distinguished from the true caraway and parsnip by odor and taste as well as by appearance.

WITCH-GRASS. *Agropyron repens.* 31 per cent.
(Quack-grass, Knot-grass, Twitch-grass, Wheat-grass.)

GOLDEN ROD. *Solidago sp.* 31 per cent.
(Yellow-weed, Fire-weed.)

YELLOW DAISY, *Rudbeckia hirta.* 26 per cent.
(Yellow Cone-flower, Black Daisy, Ox-eye Daisy, Bull's-eye Daisy.)

This was doubtless reported more often than it deserves to be, owing to its conspicuousness in hayfields and its evident relationship to the old offender, the White Daisy. It is a western plant, introduced with western seeds.

PLANTAINS. 26 per cent.

There are four species of Plantain occurring as weeds in Vermont. It was in most cases impossible to determine from the report of observers which species was referred to. In all cases where the reference was clear the English Plantain, by far the worst pest of the group, was the one intended.

The two common plantains of the dooryards and roadsides everywhere, (*Plantago major* and *P. Rugellii*), grow intermingled and are hardly distinguishable to the untrained observer. They are easily separated from the other species by their broader leaves and general habit.

The English Plantain, rib grass or black plantain, (*Plantago lanceolata*) also reported to us under the quite appropriate name of hay plantain, is becoming very common in hay fields, being continually introduced in clover seed. Being most pernicious, every farmer should learn to recognize not only

the mature plant but also the seed, in order that clover seed containing it may be rejected. It is distinguished by its long narrow leaves with prominent veins or ribs and elongated flowering heads, large specimens of which somewhat resemble those of timothy.

The Western or bracted plantain (*Plantago Patagonica var. aristata*) is a fourth species which is becoming more common each year. It is a native of the west and is introduced in clover seed. Forty per cent of the samples of red clover examined last year contained seeds of this weed.

1. Bracted Plantain: *a*, entire plant; *b*, seed-capsule; *c*, same, enlarged; *d*, seed; *e*, same, enlarged.
(Dewey, Farmers' Bul. 28, U.S. Dept. Agr.)

RAGWEED. *Ambrosia artemisiaefolia.* 21 per cent.
(Roman Wormwood, Wild Wormwood, False Wormwood.)

SORREL. *Rumex acetosella.* 20 per cent.
(Sheep Sorrel)

The seeds of this weed, also, are a common impurity in clover seed, especially in alsike, and every buyer of clover seed should learn to recognize and guard against it. Eighty-three per cent of the alsike seed examined last year contained sorrel.

DOCKS. *Rumex crispus* and *R. obtusifolius.* 20 per cent.

There are several species of dock but the reports received doubtless all referred to these two species. The first (Yellow or Curled Dock) is the more troublesome, although the second (Broad-leaved or Bitter Dock) is very common and is of similar character as a weed.

HARDHACK. *Spiraea sp.* 19 per cent.

Two species of this weed occur and are not popularly distinguished, the Willow-leaved Spiraea, or Meadowsweet (*S. salicifolia*), with creamy-white flowers, occurring especially in moist low meadows, and the Steeple-bush or

Downy-leaved Spiraea (*S. tomentosa*), with rose-colored flowers, occurring more especially in hill pastures. The two are similarly troublesome as weeds.

2. TEN SERIOUS OFFENDERS OCCURRING LESS GENERALLY.

CHICORY, *Cichorium Intybus*, 14 per cent.

(Blue Bells, Blue Devil, Blue-weed.)

This is very hard to eradicate where fully established, and is the most troublesome weed occurring in many localities.

2. Chicory. (Kains, Bul. 19, Div. Botany, U. S. Dept. Agr.)

MILKWEED, *Asclepias Cornuti*, 14 per cent.

(Wild Cotton.)

Locally very troublesome in most meadows.

FERNS, 14 per cent.

(Brakes, Pasture Brakes, Bunch Brakes, Sweet Fern.)

Several species of ferns form serious weeds in pastures, the most common being the Sweet-scented Fern, *Dicksonia pilosiuscula*, the Wood Fern, *Aspidium Thelypteris*, and the Eagle Fern, *Pteris aquilina*.

PIGWEED, *Chenopodium album*, 13 per cent.

CANADA THISTLE, *Cnicus arvensis*, 11 per cent.

BUTTER AND EGGS, *Linaria vulgaris*, 11 per cent.

(Snap-dragon, Jacob's Ladder.)

WILD PARSNIP, *Pastinaca sativa*, 10 per cent.
(Meadow Parsnip.)

SMARTWEED, *Polygonum sp.* 9 per cent.
(Heart's-ease, Heart-weed, Heart-see.)

LIVE-FOREVER, *Sedum Telephium*, 9 per cent.

HEMP NETTLE, *Galeopsis Tetrahit*, 7 per cent.
(Bur-weed, Brigham-weed, Thompson-weed, Joe Stevens.)

3. A DOZEN WEEDS ABOUT WHICH MORE INFORMATION IS DESIRED.

3. Blue Thistle or Viper's Bugloss. (Fletcher, Bul. 28, Exp. Farm, Canada.)

BLUE THISTLE, *Echium vulgare*, 7 p. c.

(Blue-weed, Blue Jackson, Blue-joint, Purple Thistle, Russian Thistle.)

This promises to be an increasingly troublesome weed. It is not generally distributed in Vermont as yet, but is slowly spreading. It is unfortunate that the name "Russian thistle" should be applied to this plant, as it is an entirely different thing. The true "Russian thistle" has not as yet been found in Vermont.

SHRUBBY CINQUEFOIL, *Potentilla fruticosa* 7 per cent.

(Prairie-weed, Sage-brush, Manchester-weed.)

Locally a most serious weed in rocky hill pastures. It presents one of the most interesting of weed problems, and we shall especially appreciate any further information as to its occurrence, or modes of destroying it.

GOAT'S-BEARD, *Tragopogon pratensis*, 6 per cent.

(Wild Salsify, Wild Vegetable-oyster.)

A tall, slender plant with milky juice, the leaves and root closely resembling those of the vegetable-oyster of the garden. It is, however, easily-distinguished from that by its conspicuous yellow flowers (the garden salsify

having blue flowers.) A recent invader, becoming much too common in Addison and Chittenden counties at least.

SPURRY, *Spergula arvensis*, 4 per cent.

(Devil's-gut, Devil's-weed, Peony, Piny.)

We have little information as to how general or serious a weed this is, and should be glad to learn more about it.

INDIAN-POKE, *Veratrum viride*, 3 per cent.

(Poke-root, Hellebore.)

A coarse weed in wet meadows and woodlands. The roots are very poisonous, and one man reports that the leaves in hay made cows sick in winter. Further statements are desired of experience or observations regarding the poisoning of animals by this plant.

CREEPING SOW-THISTLE, *Sonchus arvensis*, 2 per cent.

(Spreading swine.)

A rather tall thistle, with a showy yellow flowering head; distinguished from the common sow-thistle by having larger flower heads (nearly as large as a silver dollar), and creeping rootstalks. Apparently invading the state from the northwest and mostly confined at present to the shores and islands of Lake Champlain.

4. Bird Vetch or "Wild Peas." Is it a weed or a useful forage plant?
(Smith, Bul. 2, Div. Agrost. U. S. Dept. Agr.)

BIRD VETCH. *Vicia Cracca*. 2 per cent.

(Wild Peas, Canada Peas.)

This has frequently been reported to us as a weed, becoming quite common in old meadows. It is quite possibly a friend in disguise, however, as it is a member of the pea family, and may prove worthy of cultivation as a forage plant.

SWEET-GRASS. *Hierochloa borealis.* 1½ per cent.

(Vanilla or Seneca-grass, Indian Hay.)

This is a troublesome weed-grass in the western Canadian provinces, and it has been seriously complained of by several Vermont farmers. It is easily distinguished from all other grasses by its sweet odor and general appearance, since the only other odorous grass occurring here is Sweet Vernal, which looks very different. Sweet-grass has running root stalks like Witch-grass but they penetrate more deeply.

5 SWEET-GRASS. *Hierochloa borealis.*

SQUIRRELTAIL-GRASS. *Hordeum jubatum.* 1 per cent.

This grass is closely related to cultivated barley and somewhat resembles it, except that the heads are more slender and the awns longer. It is a serious weed pest in the west, and is being introduced with western seeds. It should be recognized and destroyed.

TALL MALLOW. *Malva verticillata.* 1 per cent.

The leaves, flowers and fruit of this plant closely resemble the round-leaved mallow or "cheese plant" so common about weedy yards. The tall mallow, as its name indicates, grows erect three feet or more in height, resembling a small hollyhock in general habit. It is a pernicious weed in certain old gardens of Burlington and Middlebury, and probably elsewhere.

SAND-BUR. *Cenchrus tribuloides.*

This is a grass of which the fruit develops into an offensive spiny bur. It is another western plant which is making its way into Vermont. In this case the invasion seems to be proceeding from the southeast, the reports of this weed being from the vicinity of Brattleboro, where it occurs in the meadows along the Connecticut river.

Clover Dodder. *Cuscuta epithymum.*

The dodders are destructive parasites upon the clovers and other plants, and are apparently becoming more abundant in Vermont. The seeds are introduced with clover. dodder seeds being found in 2 of the 32 samples of clover seed examined last year. The dodder forms yellowish thread-like stems which twine about the clover plants and soon kill them. Once established in the field the dodder spreads from plant to plant, forming circular patches in which the clover plants are killed. There are several species of dodder, although only one has been reported to us as troublesome in Vermont. We should be glad to receive specimens of any observed that we may learn the occurrence and distribution of the different kinds.

6. Dodder on clover-plant; *a*, flower; *b*, corolla detached and spread out, showing inner surface; *c*, mature seed pod; *d*, seed and outline of tranverse section of same.
(Dewey, Circ. 14, Div. Bot. U. S. Dept. Agr.)

Prickly Lettuce. *Lactuca scariola.*

This is closely related to the common garden lettuce which it somewhat resembles when in blossom, but is a coarser plant with prickly leaves and stem. It is a troublesome weed not only in cultivated ground but also in meadows and pastures. In the states to the west and south of us it is rapidly becoming a dreaded pest and undoubtedly will soon be introduced quite generally into Vermont. At present the only places where it is known to occur are at St. Albans, where it was probably brought in by the freight cars, and in Rutland, where it occurs in gardens.

7. Prickly Lettuce: *a*, entire plant; note the peculiar habit of the leaves so twisting that the upper part of the blade becomes vertical; the leaves then point nearly north and south, forming a "compass plant"; *b*, a single leaf enlarged to show the prickles along margin and mid rib; *c*, "seed" with appendages.
(Dewey, Farmer's Bul. 28, U. S. Dept. Agr.)

4. FIFTY OTHERS OCCASIONALLY REPORTED.

Barnyard-grass. *Panicum Crus-galli.* 6 per cent.
Bed-straw. *Galium sp.* 1½ per cent.
Bull Thistle. *Cnicus lanceolatus.* 1 per cent.
Bladder Campion. *Silene Cucubalus.* 1½ per cent.
Bladder Ketmia. *Hibiscus Trionum.* 1 per cent.
Burdock. *Arctium Lappa.* 6⅔ per cent.
Buttercup. *Ranunculus acris.* 4 per cent.
Caraway, *Carum Carui.* 9 per cent.
Chess. *Bromus secalinus.* 2 per cent.

Chickweed. *Cerastium sp.*, etc. 4 per cent.
Cinquefoil. *Potentilla Norvegica.* 1½ per cent.
Cocklebur. *Xanthium sp.* 1 per cent.
Crab-grass. *Panicum sanguinale.* 1 per cent.
Dandelion. *Taraxacum officinale.* 1 per cent.
Devil's Pitchforks. *Bidens frondosa.* 1 per cent.
Dropseed-grass. *Muhlenbergia Mexicana.* 1 per cent.
Elecampane. *Inula Helenium.* 2 per cent.
Evening Primrose. *Oenothera biennis.* 2 per cent.
Fall Dandelion. *Leontodon autumnalis.* 1 per cent.
Fleabane (White-top.) *Erigeron sp.* 4 per cent.
Golden Ragwort. *Senecio aureus*, 3 per cent.
Hedge Bindweed, (Woodbine.) *Convolvulus sepium.* 1 per cent.
Hop-clover. *Trifolium agrarium.* 2 per cent.
Horse Radish. *Nasturtium Armoracia.* 1½ per cent.
Horsetail, (Mare's tail.) *Equisetum sp.* 1 per cent.
Hound's-tongue, (Beggar's-lice, Sheep-burs.) *Cynoglossum officinale.* 3p. c.
Indian Tobacco. *Lobelia inflata.* 1 per cent.
Mallow, (Malice.) *Malva rotundifolia.* 1 per cent.
Mountain Sage. *Antennaria sp.* and *Gnaphalium sp.* 2 per cent.
Mullein. *Verbascum Thapsus.* 1 per cent.
Pepper-grass. *Lepidium intermedium.* 3 per cent.
Pigeon-grass, (Foxtail.) *Setaria sp.* 5 per cent.
Purslane, (Pusley, Parsley.) *Portulaca oleracea.* 5 per cent.
Redroot. *Amarantus retroflexus.* 1½ per cent.
Rush. *Juncus tenuis*, etc. 1 per cent.
St. John's-wort. *Hypericum perforatum*, 3 per cent.
Shepherd's Purse. *Capsella Bursa-pastoris.* 2 per cent.
Skunk Cabbage. *Symplocarpus foetidus.* 1 per cent.
Spreading Dogbane. *Apocynum androsaemifolium.* 1½ per cent.
Spurge. *Euphorbia sp.* 1 per cent.
Sunflower. *Helianthus decapetalus.* 2 per cent.
Thistle. *Cnicus sp.* 2 per cent.
White-grass. *Danthonia spicata.* 2 per cent.
Wild Blackberry. *Rubus villosus.* 1 per cent.
Wild Buckwheat, (Wild Bean, Bindweed.) *Polygonum Convolvulus.* 5 p. c.
Willows. *Salix sp.*
Yellow Rocket. *Barbarea vulgaris.* 1 per cent.
Zizia. *Zizia aurea.* 1 per cent.

IMPURITIES OF VERMONT CLOVER SEED.

The use of red and alsike clovers in Vermont is growing each year, and this increase is destined to continue. This fact certainly promises well for the agricultural interests of the state. On the other hand clover seed is generally recognized as one of the worst channels through which new or pernicious weeds are introduced into our fields. This condition is becoming so general and the weed problem is assuming such menacing proportions that a committee of the last legislature sought the advice of the experiment station regarding the advisability of passing a law concerning inspection of seeds. The Maine legislature has already enacted such a law requiring that "every lot of seeds of agricultural plants whether in bulk or in packages, containing one pound or more, and including seeds of cereals, except sweet corn, grasses, forage plants, vegetables and garden plants, but not including those of trees, shrubs, and ornamental plants which are offered for sale in the state, shall contain a written guarantee of per cent of purity."

The problem of seed control is receiving the attention of other states also, and of the department of agriculture at Washington. Whatever be the outcome, it is essential to a proper understanding of the question that we have more exact knowledge as to the actual condition of the seeds placed on our markets.

Hoping to gain such knowledge, a request for samples of commercial clover and grass seeds was sent in the spring of 1897 to 25 farmers in various portions of the state. With each sample we requested statements as to when and where it was bought and the price paid. In this way 34 samples of clover seed were obtained. A five-gram sample (a bulk equal to about one tablespoonful) of each of these was carefully examined for purity.* The impurities were divided into two classes: (1) *inert matter*, including chaff, straws, dirt, broken foreign seeds, etc.; (2) *viable seeds*, including all foreign seeds which were apparently sound. These viable seeds were further assorted, the species of each kind determined and the numbers counted.

Twelve samples of alsike and twenty of red clover were thus examined. The results are shown in the following tables, the red clover above and the alsike below the cross line:

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*L. W. Barton, a student in the agricultural department of the University, made the study of the impurities of Vermont clover seed the subject of his senior thesis investigation and determined the purity of these samples. Our thanks are due him for the painstaking manner in which this was done.

IMPURITIES IN RED AND ALSIKE CLOVER SEED.

Sample number	SENT BY	Where bought	Price per pound	Per cent of total impurities.	Per cent of inert matter	Per cent of foreign seeds	No. noxious foreign seeds	No. useful foreign seeds	No. of kinds of weeds	Remarks on nature of impurities, etc.
			Cts.							
1	O. J. Lowry.......	Boston...........	10	4.40	3.00	1.40	12	124	7	Chiefly timothy.
3	C. M. Winslow.....	Burlington.......	10	1.73	.47	1.26	36	4	7	Considerable English plantain.
4	" "	....	10	2.15	1.29	.86	61	9	11	Ditto, with bracted plantain, etc.
7	J. O. Sanford......	No. Adams, Mass	8¾	.07	.04	.03	8	2	2	No bad weeds.
9	J. K. Curtis.	St. Albans.	10	.70	.47	.23	11	1	5	A little English plantain.
11	L. M. Macomber...	Ferrisburgh.....	11	.48	.01	.47	26	31	4	A little sheep sorrel.
12	" " ...	"	11	.60	.14	.46	19	3	8	Some English plantain, also bracted plantain.
16	P. D. Jameson	Alburgh.........	10	1.44	.45	.99	70	16	9	Chiefly pigeon and finger grasses.
17	T. L. Kinney.......	Boston...........	....	3.03	.48	2.55	132	7	11	Much Eng. plantain, sorrel, carrot & dodder.
19	T. P. Gordon......	Plattsburgh, NY.	....	.30	.01	.29	15	3	6	Chiefly finger grass. (P. glabrum.)
20	B. P. Ruggles.....	Hartland	9	3.03	1.60	1.43	58	14	9	Much sorrel and Eng. plantain, some bracted plantain.
21	" "	"	9	5.25	2.08	3.17	192	75	15	Ditto, very bad condition.
23	F. S. Hale.........	Windsor.........	10	3.67	.83	2.84	86	6	11	Chiefly pigeon grass, also Eng. and bracted plantain, etc.
24	H. C. Leavenworth	Charlotte	9½	.90	.30	.60	17	1	5	Chiefly Paspalum setaceum.
26	Expt. Station......	Wisconsin... ...	8½	.49	.23	.26	8	4	3	Chiefly pigeon grass. No bad weed.
28	L. W. Barton......	Ludlow..........	10	2.93	.95	1.98	92	27	15	Sorrel, docks, pigeon and finger grasses, plantain, etc.
29	Expt. Station......	Burlington	10	1.99	.53	1.46	66	6	8	Much Eng. plantain, some sorrel and dock.
30	"	"	10	2.07	1.49	.58	91	...	..	Chiefly Eng. and bract. plantains. Bad case.
34	W. R. Bliss........	Corinth	....	1.42	.53	.89	33	7	4	No very bad weeds.
2	O. J. Lowry.......	Boston	10	7.12	1.94	5.18	101	226	6	Chiefly sheep sorrel.
5	C. M. Winslow....	Burlington	10	3.30	.57	2.73	100	263	9	Much sheep sorrel.
6	" "	"	12	.62	.19	.43	13	47	4	Some wild carrot.
8	J. O. Sanford......	N. Adams, Mass.	8¾	1.78	.02	1.76	16	127	5	Some sorrel and pepper grasses.
10	Fred Small........	Morrisville......	10	2.35	.34	2.01	69	186	9	Chiefly sorrel, some may weed, yellow daisy, etc.
13	L. M. Macomber...	Ferrisburgh.....	11	2.00	.49	1.51	41	164	13	Much sorrel, some pig weed, docks, pepper grasses, etc.
15	P. D. Jameson....	Swanton	10	4.34	1.02	3.32	105	298	4	Chiefly sheep sorrel.
18	S. P. Gordon	Plattsburgh, NY.	....	6.94	.93	6.01	33	696	10	Blue curls, etc.
22	D. L. Osgood......	Rutland	11	1.92	.44	1.48	27	1	11	Chiefly sorrel, much pig weed, etc.
25	H. C. Leavenworth	Charlotte........	9	2.47	.32	2.15	82	178	15	Chiefly bottle grass, much dodder.
27	G. S. Fassett	Enosburgh.......	9	5.52	1.26	4.26	70	32	7	Chiefly sheep sorrel.
31	Expt. Station......	Burlington.......	10	2.43	.72	1.71	30	184		

OCCURRENCE OF WEEDS IN CLOVER SEEDS.

LATIN NAME	ENGLISH NAME	COMMON RED CLOVER					ALSIKE CLOVER				
		Per cent of samples in which it occurred	Maximum number found in 5 grams	Equalling the following number in 1 pound	Average number in 5 grams	Equalling the following number in 1 pound	Per cent of samples in which it occurred	Maximum number found in 5 grams	Equalling the following number in 1 pound	Average number in 5 grams	Equalling the following number in 1 pound
Rumex acetosella...	Sheep Sorrel...	55	25	2250	6	540	83	94	8460	33	2970
Setaria viridis......	Bottle-grass	75	52	4700	13	1170	67	109	9810	10	963
Plantago lanceolata.	English Plant'in	65	49	4400	9	810	17	6	540	1—	54
Chenopodium album	Pigweed........	55	14	1260	3	270	67	17	1530	5	114
Setaria glauca......	Pigeon-grass....	55	6	540	2	180	8	2	180	1—	14
Panicum sanguinale	Crab-grass......	35	3	270	1—	54	33	3	270	1—	54
Rumex crispus	Curled Dock...	35	7	630	1+	126	25	2	180	1—	45
Panicum capillare..	Hair-grass......	25	7	630	1—	67	58	9	810	2—	162
Polygon'm P'rs'caria	Smart-weed.....	30	12	1080	1+	117	25	1	90	1—	22
Panicum glabrum...	Small crab-gr'ss	50	50	4500	8	750	17	3	270	1—	30
Plantago Rugellii...	Plantain	35	19	1710	4	410	17	2	180	1—	22
Lepidium Virgin'c'm	Pepper-grass. ..	0	0	000	0	00	67	15	1350	2+	243
Plant. Pat. var. arist.	Bracted Plant'in	35	23	2070	3	297	17	7	630	1—	59
Anthemis Cotula....	May-weed	5	1	90	1—	7	33	7	630	1	90
Amarantus sp.......	Red-root........	10	4	360	1—	540	33	5	450	1—	500
Daucus carota.......	Wild Carrot....	25	27	2530	2+	250	17	4	360	1+	135
Brassica sin'pistrum	Kale	10	1	90	1—	14	17	14	1260	1—	36
C'ps'la B'rsa-past'r's	Sh'ph'rd's Purse	15	12	1080	2+	216	17	7	630	1	90
Euphorbia Preslii....	Spurge..........	20	8	720	1+	126	8	2	180	1—	16
Brunella vulgaris...	Blue Curls......	10	6	540	1—	50	8	5	450	1—	36
Silene noctiflora.....	N't fl'w'r'g C'hfly	0	0	00	0	00	17	11	990	1	90
Cuscuta sp..........	Dodder..........	5	7	630	1—	50	8	18	1620	1+	135
Paspalum setaceum	....	10	11	990	1+	117	0	0	00	0	00
Cnicus arvensis.....	Canada Thistle.	5	1	90	1—	7	8	1	90	1—	7
Rudbeckia hirta.....	Yellow Daisy...	0	0	00	0	0	8	1	90	1—	7
Euphorbia maculata	Spotted Spurge.	0	0	00	0	0	8	2	180	1—	14
Ambr'sia art'm's'f'lia	Roman W'mw'd	5	1	90	1—	7	0	0	00	0	00
Chrysan. leucanth'm	White Daisy....	0	0	00	0	0	8	3	270	1—	22
Panicum Crus-galli..	Barnyard-grass.	10	1	90	1—	14	0	0	00	0	00
Lychnis sp..........	Cockle..........	5	1	90	1—	7	0	0	00	0	00
Carex sp.....	Sedge..........	0	0	00	0	0	8	1	90	1—	7
Plantago major......	Plantain.........	5	2	180	1—	29	0	0	00	0	00
Anthemis arvensis..	Corn Ch'momile	0	0	00	0	0	17	1	90	1—	14
Barbarea sp.........	Winter Cress...	5	1	90	1—	7	8	1	90	1—	7
Poa, decorticated....	....	0	0	00	0	0	17	2	180	1—	29
Grass not det'rmined	....	5	4	360	1—	29	0	0	00	0	00
Seeds not det'rmined	....	35	4	360	1+	90	25	9	810	1+	90

These figures show a considerable difference in the condition of red and alsike clovers. These differences are two-fold, first in the quantity of impurities and second in their nature.

The quantitative differences may be summarized as follows:

A COMPARISON OF CONDITIONS IN RED AND ALSIKE CLOVER SEED

		Total per cent of impurities	Per cent of inert matter	Per cent of viable seeds	Number of weed seeds in 1 pound	Number of useful seeds	Approximate number of clover seeds in 1 pound
Red Clover	Maximum	5.3	2.1	3.2	18432	7200	
	Minimum	0.3	0.0	0.3	1440	288	
	Average	1.8	0.8	1.0	4800	1632	336000
Alsike Clover	Maximum	7.1	1.9	5.2	9600	21696	
	Minimum	0.6	0.2	0.4	1248	4512	
	Average	3.2	0.7	2.5	3744	19200	720000

It is evident from the figures that the alsike contains a greater proportion of foreign seeds. Yet further consideration shows that inasmuch as there are over twice as many clover seeds in a pound of alsike as in a pound of red clover, it is not necessary to sow over half as much alsike to the acre; and the general practice is in accord with this. The number of foreign seeds introduced on one acre seeded with the average red clover would therefore be about the same as in the case of alsike. But these foreign seeds are of two classes (1) useful seeds such as other clovers and grasses, and (2) weed seeds. If this qualitative difference in the foreign seeds is considered it will at once be seen that the alsike is much the less dangerous, since one pound of alsike contains on the average less than 4000 weed seeds, while the two pounds of red clover contains nearly 10000 weed seeds. Every sample of the alsike clover examined contained more or less timothy, this amounting in one case (No. 18) to nearly 6 per cent. There is no objection to this except that the timothy is a cheaper seed.

The most important consideration of all is the nature of the weed seeds introduced. Some which occur very commonly, such as pigeon-grass and pigweed, while wholly undesirable, are not pests which prove seriously troublesome as ordinarily introduced with clover seeds. There were several kinds of weed seeds found, however, which are most pernicious. The most noteworthy of these are sheep sorrel, English plantain, bracted plantain, wild carrot, and dodder. Sorrel was found in 60 per cent of the red clover samples examined and wild carrot in several of them. These two are already recognized as among the worst of weeds in Vermont grass lands. The English plantain which occurred in 70 per cent of these samples is less generally known to farmers, although it is becoming one of the commonest weeds in hay fields. Clover dodder is one the worst enemies of the clover plant and should not for a moment be tolerated in a Vermont field. Fortunately

there is but little of it now in the state, although it is becoming common in some other parts of the country. Two of the thirty-one samples examined contained this pest.

In considering these results it should be borne in mind that they do not represent the average grade of clover seed used, since the parties sending the samples are among the most careful and painstaking of our farmers, who intend to use only good seed. A large seedsman recently stated to us that he could furnish any grade of seed demanded, according to the price the farmer was willing to pay. A line of samples was shown which justified the statement. It ranged from seed which was almost perfectly clean, for which a good price was asked, to one which was composed of inferior seed, and contained fully 10 per cent of weed seeds and inert matter, cheap stuff in every sense. It seems quite probable that any farmer in Vermont can by intelligent effort secure high grade clover seed practically free from bad weed seeds if he is ready to pay a good price, and buy of the right parties. Yet price alone does not seem to insure this. For example, the lowest price quoted on a New England purchase was on red clover No. 7, at 8¾ cents, which proved to be by far the purest sample examined.

8. Clover seed and some of its impurities: *a*, clover seed; *b*, same, enlarged; *c*, fruiting calyx of black bindweed, inclosing seed, enlarged; *d*, seed of same; , seed enlarged; *f*, fruiting calyx of blackheart, inclosing seed, enlarged; *g*, seed of same; *h*, seed enlarged; *i*, seed of pigeon grass; *j*, same, enlarged; *k*, seed of bracted plantain; *l*, same, enlarged; *m*, seed of English plantain; *n*, same, enlarged; *o*, fruiting calyx of sorrel; *p*, same enlarged; *r*, seed of same; *s*, seed, enlarged.

(Dewey, Year-book, U. S. Dept. Agr., 1896,)

Neither is the name of a large seed house alone a sufficient guarantee. The price paid for red clover No. 17 was not stated, but it came from one of the largest seed dealers in Boston, supposedly trustworthy, and yet it was one of the worst samples examined, containing 2½ per cent of weed seeds, including English plantain, sorrel and dodder.

If the buyer is to protect himself against the introduction of these weeds, he must not only look to the general purity of his seeds, but especially he should determine whether these most serious invaders are present. A seed law to be truly useful should require not only the guarantee of general purity, but absolute freedom from certain weed-pests.

In order to aid in the recognition of these, we include figures of these more serious clover-seed weeds. The station is always ready to examine, free of charge, all samples of agricultural seeds sent it.

SAP PRESSURE AND FLOW IN THE SUGAR MAPLE.

The causes and conditions of sap flow in the sugar maple have attracted the interest of this department for several years, but the more pressing demands of other work have hitherto prevented such active and continuous investigations as the complexity of the problem demands.

In the spring of 1897 some field work was done, and much more time was given to the matter during the past season. This was rendered possible by the selection of this subject by Mr. W. J. Morse for his thesis of graduation from the agricultural department of the University Mr. Morse in the course of this work made a series of careful observations and records of the variations in sap pressure and flow during the past spring, and especially in their relation to meteorological conditions. It is hoped that he may be able to aid in the further study of these problems next year.

The season was a notably poor one for sap flow, however, and the period of flow was quite short. The problem, moreover, is one requiring the observations of a series of years for its satisfactory comprehension. It is deemed best therefore to give at this time only brief statements regarding the methods employed and a few of the more conclusive results, leaving the detailed discussion until much more data have been accumulated.

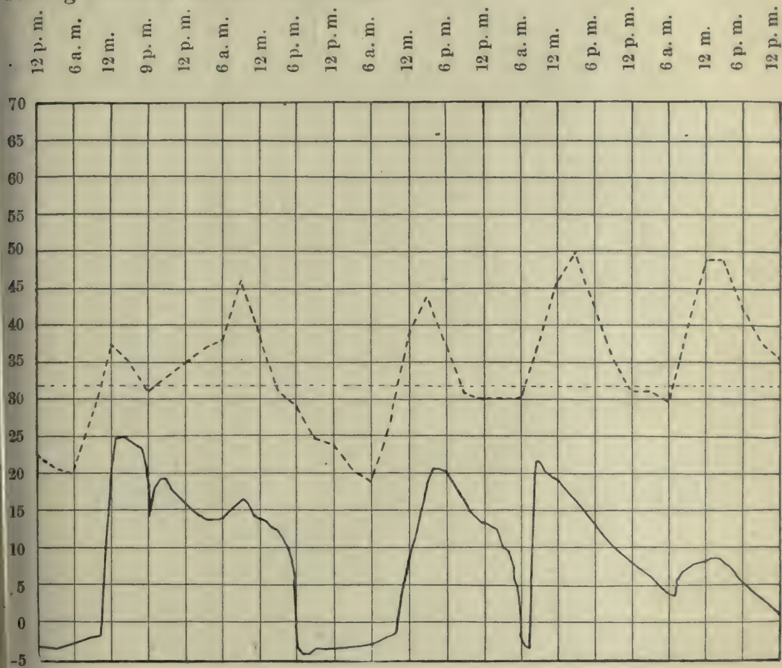
METHODS.

One of the most obvious and most interesting parts of the problem is that which deals with the relations of sap pressure and temperature. In order to make the records of the fluctuations of much value for comparative study, observations must be made at short intervals of time, while continuous records are obviously of even greater value. By means of a Draper self-recording thermometer such a continuous record of the temperature was obtained at the point of observation, throughout the period of sap flow. Partially continuous records of sap pressure were similarly secured by the use

of a Crosby self-recording pressure gage. This is designed for record ing steam pressure, but with certain minor changes was found admirably suited for the recording of sap pressure.

The comparison of these two records is extremely interesting and promises to be even more so in a more favorable season of sap flow

The following diagram will illustrate both the character and the value of the records thus far obtained. It is only one of the numerous charts representing the observations of the season:



............Temperature. ———— Pressure or suction.

The close relation existing between sudden rises of temperature and of sap pressure is of course obvious, as is also the fact that the line of pressure is somewhat more tardy in its general rise and fall than is that of temperature. The full explanation of all the fluctuations that occurred during the season is, however, a matter of greater difficulty.

The relation of the pressure at different heights of the tree was also a matter of observation in similar ways. By means of tree thermometers the fluctuations in temperature within the body of the tree as compared with those of the air were also learned. One of the interesting problems in this connection is the relation of freezing temperatures to sap-pressure.

DOES SAP FLOW UP OR DOWN?

The direction of the sap flow in the tree during the sugar season is a matter upon which there is difference of opinion. To test this point lithium chlorid, a chemical readily detected in the minutest quantities, was injected into the tree, its presence in the sap being determined by the spectroscope.

The results showed conclusively that in the ordinary conditions of sap flow there is an almost equally rapid movement of the sap current both upwards and downwards in the vicinity of the sap spout. Similar methods were used to determine the existence or non-existence of lateral flow, but the results were entirely negative. These experiments will all be repeated another spring, but the conclusion seems clear that the sap moves freely in both directions *with* the grain of the wood, but very slowly *across* the grain.

The rapidity of the passage of the lithium both upwards and downwards is shown by the following records, which are but samples of a considerable number of similar observations.

A tree was tapped on the southwest and southeast sides and lithium injected one foot above (southwest) and one foot below the tap-hole (southeast). The sap was running 80 drops to the minute. Spectroscopic examinations resulted as follows:

March 30, 2.28 P. M.,	before injection	No lithium
" 30, 2.34 "	5 minutes after injection	" "
" 30, 2.39 "	10 " " "	Lithium abundant
" 30, 2.44 "	15 " " "	" "
" 30, 3.20 "	51 " " "	" "
" 31, 1.20 "	23 hours " "	" "
April 2, 1.50 "	3 days " "	No lithium
March 30, 2.30 P. M.,	just before injection	No lithium
" 30, 2.36 "	5 minutes after injection	Faint trace of lithium
" 30, 2.41 "	10 " " "	Lithium abundant
" 30, 2.46 "	15 " " "	" "
" 30, 3.20 "	49 " " "	Lithium very abundant
" 31, 1.20 "	23 hours " "	" abundant
April 2, 1.50 "	3 days " "	Faint trace of lithium

A second tree was similarly tapped one tap being upon the east side of the tree, the other upon the west side. It ran very rapidly, at the rate of over 200 drops per minute. Lithium solution was injected on the west side two feet below, and on the east side two feet above the taphole; three samples were taken at intervals of 5 minutes, and showed the following results:

West side, lithium injected two feet below tap at 2.25 P. M.

Sample taken before injection		No lithium
2.30 P. M.,	5 minutes after injection	" "
2.35 "	10 " " "	Lithium abundant

East side, lithium injected two feet above tap at 2.24 P. M.

Sample taken before injection		No lithium
2.29 P. M.,	5 minutes after injection	Trace of lithium
2.34 "	10 " " "	Lithium abundant

A quite unexpected result was the rapid decrease in amount of the lithium, ending in some cases in its total disappearance from the sap within 24 hours. Of course only a small amount was injected at first, but the sensitiveness of the spectroscopic test is so great that one might naturally expect that traces of the salt would be found for many days afterward. Most of it was apparently washed out through the tap-hole in a few hours.

REPORT OF THE BOTANISTS

L. R. Jones and W. A. Orton

Most of the time in this department has been given to the study of plant diseases and their prevention. The topics in these and other lines in which the work has reached a stage to justify publication are indicated below.

Three additional subjects have received considerable attention, namely, a bacterial rot of carrots and other vegetables, the agricultural grasses and the phenemena of maple sap pressure and flow. It is not deemed expedient to discuss these studies in their present state of incompletion.

The subjects which are discussed are placed in following order:

Potato diseases and their remedies.

I. Potato diseases as they occurred in 1898.

II. Results of spraying potatoes in 1898.

III. Studies on the time and rate of development of the potato tuber.

Apple diseases and their remedies.

I. Spraying for the prevention of the apple scab.

II. The brown spot disease of apples.

A second partial list of the parasitic fungi of Vermont.

Killing weeds with chemicals.

POTATO DISEASES AND THEIR REMEDIES

I. POTATO DISEASES AS THEY OCCURRED IN 1898

The season was more favorable for potatoes than that of 1897, but the yields at Burlington were not large even with the best locations and culture. This was chiefly due to a period of drought in midsummer, there being but little rainfall between the middle of July and the middle of August. As a result practically all potatoes on light soils died during this period with the characteristic symptoms of tip-burn, while those more favorably situated suffered severely. The general appearance of tip-burn in such potato fields during the latter part of July closely following the attacks of the main brood of the flea beetles again emphasizes the close relationship which has been observed heretofore between the injuries of this insect and the "burning" of the foliage. The extent of the damage done by the flea beetle, especially in dry seasons, is generally underestimated.

The plants sprayed with bordeaux mixture were relatively exempt from the flea beetle attacks and also showed comparatively little tip-burn.

There was very little of either of the fungus diseases, the early and the late blights, (*Alternaria Solani* and *Phytophthora infestans*) upon the experiment station fields, or elsewhere in the vicinity of Burlington. Considerable damage from the late blight and the rot were, however, observed at several points in the interior of the state and reports indicate that where the weather was sufficiently moist there was the usual loss from this disease.

There was evidence of arsenical poisoning in many fields especially during July.

II. RESULTS OF SPRAYING POTATOES IN 1898

Experiments were planned in continuation of those of former years to determine the relative values of various forms of bordeaux mixture for use in spraying potatoes. Trial was made also of certain articles placed upon the market as combined fungicides and insecticides. Inasmuch as there was practically no development of fungus diseases upon any of our plots the trial of these compounds was of little significance, so far as concerns their fungicidal values. The results showed rather the value of the different preparations in protecting the plants from insect ravages chiefly those of the flea beetle and in preventing the death of the foliage from tip-burn, a trouble which as already stated is closely associated with insect injuries. In addition to its protection against insects and fungi the bordeaux mixture apparently so increased the general vigor of the foliage as to lessen the damage from tip-burn.

The forms of bordeaux mixture under trial were:

1. Standard bordeaux mixture.—1½ pounds copper sulphate, 1 pound lime, 10 gallons water. The lime and sulphate solution were each diluted with one-half the total amount of water, the latter then poured into the former and the mixture thoroughly agitated; freshly made as applied.

2. Improperly made bordeaux mixture.—This mixture contained the same proportions of lime and copper sulphate as did the standard but the method of combining them was different. The *concentrated* lime water (1 pound lime in 1 gallon water) was added to *concentrated* sulphate solution (1 pound sulphate in 1 gallon water), and this mixture stirred and then diluted. It has been shown [1] that a mixture so made is distinctly inferior in its mechanical properties and probably so in its chemical composition to one properly made, yet most of the directions for preparing this mixture given in the popular press and many of those in experiment station literature would, if followed, result in this inferior kind of a preparation.

3. Commercial bordeaux mixture.—There is a demand for a commercial form of bordeaux mixture which is supplied in a legitimate manner by man-

1 Vt. Sta. Rpt. 9, p. 88 (1895).

ufacturers who have placed upon the market a concentrated mixture in sealed packages to be diluted for use. These concentrated commercial mixtures must in all cases be made in substantially the manner cited under 2, above; and since the mechanical properties of bordeaux mixture deteriorate upon standing, it seems beyond question that any such concentrated mixtures must be distinctly inferior to that which is freshly prepared and properly made. Wishing, however, to determine the facts by actual test rather than to rely upon theoretical considerations alone, the "Lion Brand" of bordeaux mixture was included in the series. This was diluted according to directions and the same quantity of this diluted mixture was applied as of the other bordeaux mixtures.

The following results are averages deduced from a series of 20 plots.

COMPARATIVE TESTS OF VARIOUS FORMS OF BORDEAUX MIXTURE

Fungicide used	Dates of applications	Average yields in bushels per acre	
		marketable tubers	small tubers
Standard bordeaux mixture, 3 times	July 21 Aug. 9 Sept. 9	239	28
Improperly made bordeaux mixture, 3 times	July 21 Aug. 9 Sept. 9	230	28
Standard bordeaux mixt., 2 times	Aug. 9 Sept. 9	186	20
Commercial bord. mixt., 2 times	Aug. 9 Sept. 9	159	34
Check, no fungicide	Paris-green enough to destroy Colorado potato beetles.	112	42

DISCUSSION OF THESE RESULTS

The more important conclusions to be drawn from these experiments in our judgment are as follows:

1. *Standard bordeaux mixture.—Three applications* more than doubled the yield where properly used; and this in the absence of fungus diseases.

Two applications were remarkably inferior to the three. This was because the flea beetle and drought combined did the greatest damage before August 9th, the date of the first sprayings on these plots. Nearly one half of the benefit from the use of the mixture was thus lost. On the other hand under the climatic conditions of 1898, two applications made say July 21 and August 10th would probably have insured nearly as large gains as did the three noted above. In other words to insure the best protection the spraying should be given so early as to be distinctly in advance of the main

brood of the flea beetles which appeared about July 25 in 1898. Whether one or two later applications are given should depend upon various conditions including those of variety, weather and of the occurrence of diseases.

2. Improperly made bordeaux mixture proved somewhat inferior to the standard as judged by yield. It was, moreover, more difficult to apply owing to the coarser character of the precipitate. This condition necessitated more frequent agitation, made uniformity in application very difficult and led to more trouble from the clogging of the nozzles. It also appeared to be less adhesive to the foliage than did the properly made mixture.

3. Commercial bordeaux mixture proved to be distinctly inferior to the standard bordeaux mixture. It was open to the practical objections just urged against the improperly made mixture but to a much greater degree. Uniform application was practically impossible as the precipitate was coarse grained and settled very rapidly. It also troubled a great deal by clogging the nozzles. The price of this "Lion Brand" is $1.50 for the can which is to be diluted to 50 gallons. This makes the price 3 cents a gallon for the diluted mixture, whereas the chemicals required for home-preparation of the standard mixture cost one cent or less a gallon. The commercial mixture cannot therefore be considered a successful substitute for the home-made mixture except for small operations in gardens and green-houses. In these its use can be defended solely on the ground of its convenience.

BUG DEATH AND LAUREL GREEN [1]

Two commercial powders, bug death and laurel green, are being offered in the Vermont market as substitutes for paris green and bordeaux mixture for use on potatoes. The former is claimed to be non-poisonous and both are said to be preventives of insects and blights. As numerous inquiries relative to these powders were received we decided to test their merits, as compared with bordeaux mixture. The question of first importance in our mind in planning these experiments was as to whether or not these powders had fungicidal value. The trial rows were therefore treated alike with paris green until the use of bordeaux mixture was begun on the adjacent plots. Alternate rows were thereafter treated with bordeaux mixture, bug death and laurel green, check rows being treated with enough paris green to keep off the Colorado potato beetles.

In order to give these compounds the fairest and fullest opportunity to prove their merits the quantity of each used was far in excess of that recommended on the packages. Approximately 45 pounds per acre was applied at each date, which is many times as much as would usually be advised. Three applications were made at the dates when bordeaux mixture was used on the other plots, viz: July 21, August 9, September 6. The compounds are both in the form of fine powders and are most conveniently

[1] See analyses in report of chemists, p. 147.

applied in the dry form. They were so used upon part of the plots; upon others they were mixed with water and applied with the spray pump.

As stated above the object of the trial was primarily to determine if these compounds had value as fungicides. In the absence of fungus diseases this was not accomplished. The vines were, however, well protected against the Colorado beetle by both substances and, moreover, used in this excessive amount, both alike served to check the attacks of the flea beetle to a very considerable degree. The benefits accruing were therefore appreciably greater than came from the usual applications of paris green. On the other hand the plots where these powders were applied were less adequately protected against insects and showed more tip-burn than did these sprayed at the same dates with bordeaux-paris-green mixture.

These facts were best shown by the relative condition of the foliage of the various plots during the latter part of August and first part of September. They are also indicated by the following tabular summary of the yields of marketable tubers in bushels to the acre:

Bordeaux mixture, 3 applications	239
Bug death, 3 applications each of 45 lbs. per acre, applied dry	209
Same, but applied with water	219
Laurel green, 3 applications each of 45 lbs. per acre, applied dry	174
Same, but applied with water	167
Check	112

Conclusions.—The results showed that both laurel green and bug death have value as preventives of insect injuries to potatoes. It is not fair to conclude from our experiments what that value is as compared with paris green since we used amounts of these far in excess of those recommended or practicable in regular commercial conditions. Even with these extremely liberal applications they were inferior to bordeaux mixture. In both cases slightly better results were obtained by applying them in water, probably because of more uniform application and better adhesion to foliage. Their value as fungicides was left undetermined.

III. STUDIES ON THE TIME AND RATE OF DEVELOPMENT OF THE POTATO TUBER

Studies along this line were made in 1893[1] and the results were of so much interest and value in judging of the importance of spraying that we have desired to repeat the observations. For this purpose some seventy-five rows of potatoes were staked out across one end of our field. One half of these were White Stars, the other half were Delawares. All were planted May 16, on rather heavy clay soil. The use of paris green in the earlier part of the summer and three applications of bordeaux mixture in the lat-

1 Vt. Sta. Bul. 40, p. 26 (1893).

ter part kept these vines in fairly healthy condition in spite of the severe drought and insect attacks of July and August. Digging was begun in August 4, every ninth row being dug on that date. Ten days later a similar digging was made and so on at intervals of as nearly ten days as weather would permit, records of yields being kept. The two varieties developed so similarly that the results from them are averaged together.

The yields at each of the dates of digging are summarized below in terms of bushels to the acre. For purposes of comparison the results of the former year are also included in this table.

White Star, planted May 20, 1893				White Star and Delaware, planted May 16, 1898		
	Total yield	Yield of marketable size			Total yield	Yield of marketable size
Aug. 2	58	----		Aug. 4	92	65
" 12	115	----		" 15	99	76
" 22	230	163		" 24	116	88
Sept. 1	304	234		Sept. 3	153	130
" 12	356	303		" 13	172	152
" 22	379	353		" 26	197	181
				Oct. 6	226	209

Some conclusions may profitably be drawn from the above table.

It is to be noted in the first place that there was quite uniformly good growing weather throughout the summer of 1893, whereas there was a severe drought during July and August, 1898, hence the results were more representative in 1893 than in 1898.

In both seasons a considerable portion of the ultimate yield of marketable tubers was formed after September 1st. In 1893 only one-half of the total yield of marketable tubers was formed on August 24th, in 1893 this point was reached August 28. In view of this fact it is significant to recall the condition of the average *unsprayed* potato fields during the last week of August. In our own plots in 1898 the unsprayed vines were nearly all dead before August 20th, and the small yield on these unprotected plots (112 bushels an acre on the unsprayed plots as contrasted with 239 on those sprayed) is the natural consequence. We are lead to repeat with emphasis the statement made in the report of 1893 that *the potato crop of Vermont suffers far more each year than is generally realized from the premature death of the vines.*

APPLE DISEASES AND THEIR REMEDIES

I. SPRAYING FOR THE PREVENTION OF APPLE SCAB

Mr. A. H. Hill of Isle La Motte kindly continued during 1898 the experiments which were discussed in our last report.[1]

These experiments were planned by Mr. Hill with the advice of the writers and were designed to afford information as to the relative gains from

1 Vt. Sta. Rpt. II, pp. 195-198 (1898).

a larger or smaller number of sprayings of apple trees with bordeaux mixture for the prevention of scab. Mr. Hill's large orchard of Fameuse trees is admirably adapted to the work. From the experimental standpoint it would have been desirable to use a larger block of trees in order to secure averages from duplicated results. The trees were, however, carefully selected and may be considered as showing practicable results.

The main body of Mr. Hill's orchard was sprayed five times. A block of five trees near the middle of the orchard was labeled for experimental spraying. One of these was sprayed twice, another three times, another four times, a fourth, like the body of the orchard, was sprayed five times and a fifth was given the same treatment with an additional application of paris green. In this spraying three different solutions were used as follows:

A. Paris green, 1 lb. in 200 gallons of water.

B. Copper sulphate, 1 lb. in 23 gallons water.

C. Bordeaux-paris-green mixture: 12-18 pounds copper sulphate, 8-12 pounds lime, 1 pound paris green, 200 gallons water.

The bordeaux mixtures were rather more dilute than is generally re - ommended by this experiment station, but Mr. Hill believes he has had more satisfactory results in practice from using dilute solutions and making proportionately more liberal applications. The stronger mixture (18 pounds sulphate, 12 pounds lime) was used in the first three applications, and the weaker one (12 pounds sulphate, 8 pounds lime) in the last two.

The dates and nature of the applications on the experimental trees were as follows:

Tree 1. Sprayed twice with A, June 4 and June 20.

Tree 2.[1] Sprayed 3 times; with B, April 25; with A on June 4 and 20.

Tree 3. Sprayed 4 times; with B, April 25; with C on May 13; with A on June 4 and 20.

Tree 4. Sprayed 5 times; with B, April 25; with C on May 13 and 28; with A on June 4 and 20.

Tree 5. Sprayed 6 times, the same as tree 4 with addition of C on June 15.

It will be observed that two extra applications of paris green were made during May and June, Mr. Hill judging that these were needed to destroy the forest tent-caterpillars which appeared in alarming numbers. The results obtained on tree 5 would ordinarily be insured without the two applications of A in June.

The results were as follows:

Tree	How sprayed	Condition of fruit: No. 1	No. 2	Cider apples
1	Paris green twice	1 apple	2 pecks	3 pecks
2	" " " plus copper sulphate once	2½ pecks	7½ "	2 "
3	Same as tree 2 plus bordeaux-paris-green once	6 "	8 "	2 "
4	" " " " " " " " twice	7 "	4 "	1½ "
5	" " " " " " " " thrice	12 "	4 "	2 "

[1] By mistake one side of this tree was partly sprayed with C May 13.

These results may be shown more clearly in two other ways, first by disregarding the actual yield of the trees and stating the relative yields of each grade in per cents of the total yield of that tree.

The other method is the statement of the actual value of the crop from each tree following the values of the different grades given by Mr. Hill, viz: No. 1, $3.00 a barrel; No. 2, $1.50 a barrel; and cider apples, $0.40 a barrel. These two methods are used in the following table:

Tree	How sprayed	Per cents of each grade No. 1	No. 2	Cider apples	Value of crop
1	Paris green twice	?	40	60	$0.48
2	" " plus copper sulphate once	21	62	17	1.69
3	Same as tree 2 plus bord. paris green once	57.5	30	12.5	2.57
4	" " " " " " " " twice	56	32	12	2.80
5	" " " " " " " " thrice	67	22	11	3.56

Some conclusions.—These results are in accord with all our former experiments and with the practical experience of Mr. Hill and many other orchardists that *one cannot afford to grow apples for market without properly spraying the trees.* The actual gain will depend upon varieties, seasons and other conditions, but intelligent spraying is an indispensable factor in the best success.

These results emphasize the importance of two conclusions which have been reached in former years.

1. The very great relative importance of spraying early in the season; the application of copper sulphate solution before the leaves open and bordeaux-paris green mixture before the blossoms open being especially important.

2. One or more, usually two, applications of the bordeaux-paris green mixture after the blossoms fall are required for the best protection of such susceptible varieties as the Fameuse.

The date of the printing of this report permits us to add the following notes on the experience in this same orchard in the summer of 1899. The forest tent-caterpillar threatened to invade the orchard in such numbers that it was deemed inadvisable to leave any trees unsprayed. The season has been an unusually dry one and the mixtures have clung to the foliage very persistently. Two sprayings have under these circumstances given adequate protection. These were made as follows:

1. Bordeaux-paris green mixture, just before the blossoms opened.
2. This same mixture again as soon as the blossoms fell.

A visit to this orchard in August 1899 showed it to be in remarkably healthy condition. There had been no trouble with forest tent-caterpillars or other insects although unsprayed orchards immediately adjoining had been stripped of practically every leaf. A half hour's search passing hundreds of Fameuse trees well loaded with fruit revealed scarcely a scabby apple. A very important point is brought out in the following statement by Mr. Hill in a recent letter: "I have made a thorough investigation of

the orchard. I find more scab on the one Fameuse apple tree which was left unsprayed in connection with the experiments of 1897 and 1898 than on all the rest of my Fameuse trees together. I found only 5 scabby apples in all the rest of the orchard, whereas there were a considerable number on the tree unsprayed in the two previous seasons." It is to be noted that this condition existed in spite of the fact that this tree was sprayed as thoroughly as were the others in 1899. The greater amount of scab on this tree must therefore be attributed to the fact that the fungus had not been suppressed during the preceding two seasons.

These conditions emphasize in a remarkable manner the gain that is assured from intelligent spraying and also the encouraging fact that the results are *cumulative* so that after an orchard has been thoroughly sprayed for several seasons as has Mr. Hill's, less spraying is required to hold the scab and other pests in check. They indicate also the importance of spraying every season.

II. THE BROWN SPOT OF THE APPLE

In the fifth annual report of this station[1] mention was made of the occurrence of a fruit spot of the Baldwin apple. Examinations at that time revealed an obscure fungus inhabiting the diseased tissues. Specimens were submitted to J. B. Ellis who reported that the fungus was probably the species called by de Schweinitz *Dothidea pomigena.* Subsequent examinations of herbarium material and literature have shown[2] that *Dothidea pomigena* Schw., is a quite different fungus from the one which occurred in these spots. We have never secured satisfactory fruiting specimens of the fungus in question, and so far as we know the species remains undetermined. Since it is undoubtedly a saprophyte this becomes a matter of less economic importance.

Re-examination of these brown spots has been made by us on various occasions since our earlier publication. In most cases, especially in the autumn and early winter, no fungus has been detected in the browned tissues, and it has therefore become evident to us that the spotting was not primarily a fungus disease.

The pressure of other work prevented a more careful study of the matter, however, until the past season. Specimens of Baldwin apples were then examined, beginning with the first evidences of their spotting in the

1. Vt. Sta. Rpt. 5, p. 133 (1891).

2 Sturgis in Conn. Sta. Rpt. 21, p. 171 (1897) points out that de Schweinitz's description of *Dothidea pomigena* (*Phyllachora pomigena* (Schw.) Sacc.) agrees very well with the characters of the superficial fungus growth known as the sooty mould of the apple. Unfortunately de Schweinitz left no specimens of this fungus among his exsicatti. A careful comparison of the sooty mould with his description leaves no doubt in our mind as to the correctness of Sturgis' conclusion.

autumn before harvest. The spots in the early stage of their development were found to be covered with an unbroken epidermis and the diseased tissues were free from fungus invasion.

Careful search was also made for bacteria in the browned tissues of the spots and in the adjacent apparently normal tissues. This included both microscopic examinations and the transference with proper precautions of bits of the tissues to various culture media (bouillon, gelatin, agar and special media containing malic acid.)

In no case were bacteria found. There remained no doubt therefore in our minds that the spots were not due to the direct invasion of the tissues by fungi or bacteria.

Several facts of interest were observed, however, some of which had been noted also in previous seasons.

1. While the spotting was worse in case of Baldwins than with any other variety in Vermont, it was not confined to this variety. It was quite common on Northern Spies and was observed also on Greenings.

2. The spots were not uniformly distributed over the surface but were considerably more numerous toward the eye (apical portion) than toward the cavity of the fruit (basal portion.)

3. The spots were not confined to the surface but appeared at various depths in the flesh, the deeper ones often being overlaid by a half inch or more of sound flesh.

4. The spots were *associated in their distribution with that of the vascular bundles*, occurring at or near the ends of the veins which permeate the flesh of the fruit.

Having opportunity at this stage of the study to confer with the officers of the Division of vegetable physiology and pathology of the United States department of agriculture it was learned that Mr. M. B. Waite and Dr. E. F. Smith had made observations upon a similar spotting of apples which they were satisfied was a non-parasitic disease and which Dr. Smith considered identical with a dry spot disease described by Wortmann as occurring in Europe.

The examination of Wortmann's paper[1] leaves no doubt that the disease discussed by him under the name "Stippen" or "Stippich-werden" is identical with the brown spot of the Baldwin, although the Baldwin did not chance to be among the varieties included in his studies.

Wortmann's work has been recently critically reviewed and his conclusions reaffirmed and somewhat extended by Bschokke.[2] Numerous experiments were devised and conducted by Wortmann and others by Bsch-

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1 Wortmann, Ueber die sogenannte, "Stippen" der Aepfel. Landw. Jahrb., 21, pp. 663-675 (1892).

2 Bschokke, Landw. Jahrb. d. Schweiz, 11, pp. 192, (1897). This author gives a very complete bibliography of the German literature of the disease.

BROWN SPOT OF THE BALDWIN APPLE

Spotted apple shown in the upper figure. Cross sections through the same fruit in the lower figures. That at the right was made near the apex or eye of the apple, that at the left near the base or cavity. Note the greater development of spots in the former.

(From photographs, natural size.)

okke in connection with their studies which satisfied them of the correctness of their conclusions.

As the season was far advanced before we had access to these papers, we have not repeated these experiments. It is of course desirable that this be done with other varieties and especially with the Baldwin. Meanwhile it seems worth while to summarize our present information regarding this spot disease, including Wortmann's and Bschokke's explanation of its causes.

SUMMARIZED DISCUSSION OF THE BROWN SPOT OF THE APPLE

Characters.—This disease usually appears superficially on the fruit as small sunken brown spots scattered over the surface of the apple, but more abundantly near the eye or apical portion. These spots may appear before maturity, but usually are seen only after the apples have lain in storage some time, and tend thereafter to increase in number and size. The spots usually vary in diameter from two to five millimeters (one-twelfth to one-fifth inch). The superficial spots usually lie immediately underneath the epidermis, which in the earlier stage of their development is unbroken. Upon cutting into such a spot it is found to consist of rather dry, dead and browned tissue, extending into the flesh for a distance about equal to its diameter. Similar areas of dead and brown tissue may occur scattered at various depths in the flesh nearly to the core. Most of the above facts are well illustrated in the accompanying figures. Examination shows the spots to be associated in their distribution with the occurrence of the vessels (vascular bundles) of the fruit.

This browned tissue may have a slightly bitter flavor in the older spots, but this bitterness is not constant and in no case in our observation is it very decided.

Occurrence.—The trouble is of widespread occurrence both in Europe and in America. It is worse on some kinds of apples than on others; and upon the same kind its occurrence varies with climatic or cultural conditions, and probably with those of storage. Wortmann states that large, sappy varities and specimens are most liable to spot.

The variety pre-eminently subject to it in the northeastern United States is the Baldwin. It has already been stated that it is of frequent occurrence on Northern Spy in Vermont and not rare on Greenings. Selby records the occurrence of the Baldwin spot in Ohio and also that of.a brown spot on Northern Spy and other varieties.[1] Craig[2] reports it as occurring in the following varieties in Canada: Baldwin, Ben Davis, Fameuse, Golden Reinette, Golden Russet, Hurlbut, Lawver, Malinda, Northern Spy, Orange Winter, Patten Greening, Plumb Cider, Princess Louise, Rawle's Janet,

1 Ohio Sta. Bul. 79, p. 134-135, (1897).

2 Canada Exp. Farms, Rpt. 10, p. 172, (1896).

Canada Red, Romna, Salome, Seedling, Seek-no-further, Simbirsk No. 4 Silken Leaf, Talman, Winter Bough, Winter Rose.

Wortmann records the trouble as occurring in varying degrees upo numerous varieties in Europe as follows: Red Reinette, Golderling, Wolt man's Reinette, Hawthornden, Winter Pearman, Landsburger Reinette Stettin, Dantziger.

Damage.—The greatest damage is to the appearance of the fruit. Th bitter flavor is rarely so prominent as to be serious.

Lamson[1] who has seen much of the trouble in Baldwins in New Hamp shire says that the disfigurement of the fruit is often so great as to rende an otherwise perfect apple a second. T. B. Wilson, a large apple grower o Hall's Corner, N. Y., writes us that these spots "are a great annoyance and cause quite a loss to the orchardists of western New York." Craig, speaking of the conditions in Canada in 1896, states that while such apple are not rendered wholly unfit for use their appearance and salability were totally destroyed.

Cause.—Neither fungi nor bacteria are to be found in the earlier stages of the spot formation nor is there a constant occurrence of any such organ ism in the later stages. It is therefore a non-parasitic disease.

Wortman's observations and experiments lead him to conclude that the death of the cells in these spots is a result of the concentration of the sap following the loss of water. This water may be lost by direct transpira tion in the case of the superficial cells, or in case of the deeper cells by exces sive conduction of the water to the transpiring surface layers. The acidity of the concentrated sap is considered to be the direct cause of the injury, this injury being followed by the browning through oxydization.

Several factors may therefore enter into the problem of spot formation.

1. The amount and rapidity of transpiration. This is dependant upon the character of the epidermis, conditions of storage, etc. The fact is emphasized that *gradual* loss of sap is essential to the formation of typical spots. Thus a specimen of a variety which is subject to spot will shrivel without the appearance of spots if kept in a warm dry room. Wortmann suggests that in case of such very rapid loss of water the acid of the concen trated sap has insufficient time to act.

2. The kind and relative amount of substances in solution in the cell sap. The same degree of concentration of different solutions may not be equally injurious, hence the actual per cent of water lost in spotting and non-spotting varieties may not stand in a direct relation to their suscepti bility to the disease.

3. The conductivity of the tissues of the fruit. The original loss of water must always occur at the surface. The death of these surface cells

1 N. H. Sta. Bul. 45, p. 46 (1897).

2 Canada Exp. Farms Rpt. 10, p. 171 (1896).

may ultimately follow unless this loss is made good by the conduction to them of water from the underlying tissues. In some varieties this conduction occurs more rapidly than in others. Wortmann found that in varieties subject to spot there was relatively slow water conduction.

Bschokke considers this relative rate of water conduction to be the most important factor in deciding the susceptibility of a given variety to the spot disease.

4. The specific resistance of the protoplasm of the cells to the injurious action of the concentrated sap. This is probably greater in some varieties than in others, and it may vary also with climatic and other cultural conditions.

Remedies.—Wortmann concludes that the spotting of susceptible varieties cannot be prevented entirely, but that, since trees which are improperly cared for produce fruit of less resistance toward unfavorable influences of every sort, proper attention to fertilization and general cultural conditions is called for. He believes that moist cloudy weather, which decreases starch formation, favors the disease and that in seasons where such weather predominates an excess of nitrogenous fertilizer is especially unfavorable. He recommends a dry sunny exposure and pruning so as to admit sunlight. On theoretical grounds he believes that storage in a moist atmosphere with uniformly low temperature will lessen the development of the spots. He also suggests the probable protection which would come from wrapping the apples separately in paper to check transpiration.

Bschokke revives a suggestion from the older literature that since apples which have lost a considerable moisture from their superficial tissues by *rapid* evaporation do not spot some treatment involving this method might be employed in bad cases. It is doubtful if this will commend itself in actual practice, although it has some theoretical interest.

Lamson finds that spraying Baldwins with bordeaux mixture—about as recommended for the scab fungus—reduces the amount of spotted fruit to a remarkable degree.

The following is a summary of his results :[1]

Prevention of brown spot of Baldwin by spraying with bordeaux mixture		Per cent of spotted fruit Sprayed	Unsprayed
1895	Sprayed once before and twice after blossoming	3	55
1896	Sprayed once before and once after blossoming	10	68
	Sprayed once after blossoming	18	68
1898	Sprayed once before and twice after blossoming	22	52

These results are certainly very striking. In view of the above explanations of the cause of this disease the question of why spraying should check the tendency to spot becomes a matter of a considerable practical as well as theoretical interest.

1 N. H. Exp. Sta. Buls. 45, (1897) and 65 (1899).

In this connection it should also be observed that Craig reported[1] adversely to bordeaux mixture as a remedy for this spot, but as his conclusions were based on general observations rather than exact experiments they cannot be weighed fairly against Lamson's conclusions.

A SECOND PARTIAL LIST OF THE PARISITIC FUNGI OF VERMONT

INTRODUCTION

The following list of fungi has been prepared by W. A. Orton as a continuation of that published in the last report, pages 201–217. The previous list included the Phycomycetes, Erysipheæ, Ustilagineæ and Uredineæ. The present list includes some corrections and additions to these groups and more or less complete lists of the Exoasci, Pyrenomycetes and Fungi Imperfecti.

While this list comprises primarily the parasitic fungi, there are several species which are undoubted saprophytes and many others partially so. Since there is in nature no sharp line of distinction between saprophytes and parasites, the attempt more completely to separate them here would have lessened the scientific value of the list and added little to its usefulness in other ways.

The nomenclature follows in general Saccardo's Sylloge Fungorum. In the Pyrenomycetes Ellis and Everhart's North American Pyrenomycetes has been followed. The common names of the host plants have been given so far as possible. The place and date of collection are given in every case. The name of the collector is indicated by an initial. C. stands for H. I. Collins; G. for A. J. Grout; H. for T. E. Hazen; J. for L. R. Jones and O. for W. A. Orton. The number following the initial refers to the number of the specimen in the Vermont experiment station herbarium on which the citation is based. Unless otherwise stated it will be understood that the fungus occurs on the leaves of the host.

We are greatly indebted for assistance to the Division of vegetable physiology and pathology of the United States department of agriculture, where many doubtful specimens were taken for identification; to Dr. J. C. Arthur of Purdue university, Indiana, who has kindly looked over some of the Uredineæ; to Dr. E. A. Burt of Middlebury, who has identified many of the Pyrenomycetes and Discomycetes; to Dr. L. M. Underwood and others of Columbia university; and to the various collectors who have added to the list.

CORRRECTION TO THE FIRST LIST

P. 17, omit Puccinia Gentianæ (Strauss,) Link.

Omit, under Puccinia graminis, on Festuca pratensis and on Poa pratensis.

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1 Canada Exp. Farms, Rpt. 10, p. 171 (1896).

ADDITIONAL HOSTS FOR SPECIES PREVIOUSLY REPORTED

PHYCOMYCETEÆ

CYSTOPUS CANDIDUS (Pers.) Lev.
On Brassica Rapa, cultivated turnip. Burl., Sept. 1898 ; O. 1939.

ERYSIPHEÆ

ERYSIPHE CICHORACEARUM DC.
On Achillea Millefolium, Yarrow. Burl., Sept. 1898 ; O. 1994.
On Dahlia variabilis, Dahlia. Burl., Sept. 1898 ; O. 1989.
On Helianthus multiflorus, Double sunflower. Burl., Sept. 1898 ; O. 1993.

ERYSIPHE COMMUNIS (Wallr.) Fr.
On Clematis sp., cult. Burl., Sept. 1898 ; O. 1992.

MICROSPHÆRA ALNI (DC.) Wint.
On Viburnum Lentago, Sheepberry. Fairfax, Oct. 1898 ; O. 1987.

MICROSPHÆRA RAVENELII Berk.
On Lathyrus odoratus, Sweet pea. Burl., Sept. 1898 ; O. 1991.

PHYLLACTINIA SUFFULTA (Reb.) Sacc.
On Betula papyrifera, Paper birch. Burl., Oct. 1898 ; O. 2228.

UNCINULA SALICIS (DC.) Wint.
On Salix nigra, Black willow. Burl., Sept. 1898 ; O. 1984.

UREDINEÆ

ÆCIDIUM ASTERUM Schw.
On Solidago rugosa, Goldenrod. Burl., May, 1896 ; J. 2085.

GYMNOSPORANGIUM GLOBOSUM Farl.
I. On Pyrus Malus, Apple. Burl., Sept. 1898 ; O. 2086.

GYMNOSPORANGIUM MACROPUS Link.
III. On Juniperus Virginiana, Juniper. Burl., May, 1899 ; O. 2901.

MELAMPSORA FARINOSA (Pers.) Schroet.
On Salix caprea. Burl., Sept. 1898 ; O. 2086.

PUCCINIA POLYGONI Pers.

II, III. On Polygonum convolvulus, Bind-weed. Isle La Motte, Oct. 1898 ; O. 2073.

PUCCINIA TANACETI DC.

III. On Helianthus tuberosus, Jerusalem artichoke. Burl., Nov. 1898 ; O. 2072.

ADDITIONAL SPECIES NOT PREVIOUSLY LISTED

PHYCOMYCETEÆ

SYNCHYTRIUM ANEMONES (DC.) Wor.

On Anemone nemorosa. Burl., Aug. 1892 ; J. 1944.

On Anemone Virginiana. Burl., Aug. 1897 ; O. 1997.

EMPUSA MUSCÆ (Fr.) Cohn.

On Musca domestica, House-fly. Burl., Sept. 1892 ; J. 2226.

USTILAGINEÆ

DOASSANSIA SAGITTARIÆ (West.) Fisch.

On Sagittaria sp., Arrowhead. Burl., Sept. 1898 ; O. 2783.

UREDINEÆ

ÆCIDIUM PUNCTATUM Pers.

On Anemone nemorosa. Burl., May, 1891 ; J. 1998.

PUCCINIA RUBIGO-VERA (DC.) Wint.

II. On Festuca pratensis, Fescue. Burl., June, 1898 ; White, 1822.

II. On Poa pratensis, June-grass. Burl., July, 1898 ; H. 1823.

UROMYCES GENTIANÆ Arthur.

On Gentiana quinqueflora, Gentian, Manchester, G. 2838.

GYMNOASCI

EXOASCUS ALNI-INCANAE Kuehn (*Taphrina Alni-incanae* (Kühn.) Magn.)

On catkins of Alnus incana, Alder. Burl., July, 1893 ; J. 1948. Johnson, Sept. 1893 ; G. 1947. Beaver, Aug. 1897 ; O. 1946.

EXOASCUS CONFUSUS Atks. (*E. Pruni* Fckl.)

On young fruit of Prunus Virginiana, Choke-cherry. Burl., May 1898 ; O. 1954.

EXOASCUS DEFORMANS (Berk.) Fckl. (*Taphrina deformans* (B.) Tul.)

On Prunus Persica, Peach. Grand Isle, June, 1895 ; J. 1958.

TAPHRINA CÆRULESCENS (D. & M.) Tul.

On Quercus rubra, Red oak. Burl., Oct. 1890 ; G. 1974.

TAPHRINA RHIZOPHORA Johans.

On ovaries of Populus monilifera, Cottonwood. Burl., May, 1897; J. 1977.

PYRENOMYCETEÆ

ASTERINA GAULTHERIAE Curt.

On Gaultheria procumbens, Wintergreen. Burl., May, 1890; J. 327.

ASTERINA PLANTAGINIS Ell.

On Plantago Rugellii, Plantain. Burl., Aug. 1897; O. 2994.

ASTERINA RUBICOLA E. & E.

On Rubus strigosus, Red raspberry. Burl., Sept. 1891; C. 2024. Newfane, Sept. 1892; G. 328.

CLAVICEPS PURPUREA (Fr.) Tul. (?) Sclerotium stage only.

On ovaries of Dactylis glomerata, Orchard grass. Burl., July, 1898; J. 2032.

On ovaries of Festuca pratensis, Fescue. Burl., Aug. 1890; J. 2031.

On ovaries of Secale cereale, Rye. Burl., July, 1898; O. 2029.

DIATRYPE VIRESCENS (Schw.) Cke.

On branches of Fagus ferruginea, Beech. Johnson, April, 1895; G. 366.

DIMEROSPORIUM COLLINSII (Schw.) Thüm.

On Amelanchier sp., Juneberry. Burl., June, 1893; J. 2023.

EUROTIUM HERBARIORUM (Wigg.) Lk.

On Ranunculus abortivus in herbarium. Burl., 1897; J. 3004.

GNOMONIA FIMBRIATA (Pers.) Awd.

On Carpinus Caroliniana, Blue beech. Newfane, Oct. 1892; G. 337. Beaver, Sept. 1897; O. 2022.

GNOMONIA ULMEA (Sacc.) Thüm.

On Ulmus Americana, Elm. Burl., Oct. 1891; C. 2018. Walden, Aug. 1898; O. 2017.

HYPOXYLON COHAERENS (Pers.) Fr.

On limbs of Fagus ferruginea, Beech. Johnson, May, 1895; G. 339.

LAESTADIA COPTIS (Schw.) E. & E. (*Sphaerella Coptis* Schw.)

On Coptis trifolia, Gold-thread. Burl., June, 1898; O. 2742.

LOPHODERMIUM PINASTRI (Schrad.) Chev.

On Pinus rigida, Pitch pine. Burl., Oct. 1897; O. 2021.

On Pinus Strobus, White pine. Burl., Oct. 1897; O. 2020. Injurious.

LOPHODERMIUM RHODODENDRI (Schw.) E. & E.

On Rhododendron maximum, Groton Pond. July, 1898 ; J. 2610.

MASSARIELLA BUFONIA (B. & Br.) Speg.

On bark of Prunus Pennsylvanica, Cherry. Johnson, May, 1895 ; G. 348.

[1] SPHÆRELLA COLORATA Pk.

On Kalmia angustifolia, Laurel. Colchester, May, 1898 ; O. 2738.

SPHÆRELLA DAHLIÆ C. & E.

On Dahlia variabilis, Dahlia. Burl., Sept. 1898 ; O. 2458.

SPHÆRELLA FRAGARIÆ (Tul.) Sacc.

On Fragaria Chiloensis, Cultivated strawberry. Isle La Motte, Oct. 1898 ; O. 2014.

On Fragaria vesca. Burl., Aug. 1897 ; O. 2016.

On Fragaria Virginiana. Burl., Aug. 1897 ; O. 2015.

SPHÆRELLA IMPATIENTIS Pk. & Cl.

On Impatiens fulva, Jewel-weed. Waterbury Ctr., Aug. 1898 ; O. 2735.

SPHÆRELLA THALICTRI E. & E.

On Thalictrum dioicum, Meadow-rue. Burl., July, 1897 ; O. 2459.

NECTRIA CINNABARINA (Tode) Fr.

On Betula lutea, Yellow birch. Jeffersonville, Mar. 1898 ; O. 3029.

On Acer saccharinum, Sugar maple. Waterbury Ctr., April, 1898 ; O. 3032. (Conidial stage.)

NECTRIA COCCINEA (Pers.) Fr.

On Acer Pennsylvanicum, Striped maple. Burl., Oct. 1898 ; O. 3040.

PHYLLACHORA FLABELLA (Sch.) Thüm.

On Pteris aquilina, Brake. Grafton, Aug. 1899 ; G. A. Woolson, 3770.

PHYLLACHORA GRAMINIS (Pers.) Fckl.

On Agropyron repens, Witch-grass. Burl., Oct. 1896 ; J. 2005.

On Asprella hystrix. Burl., July, 1897 ; O. 2007.

On Elymus Canadensis, Wild rye. Burl., Oct. 1891 ; C. 2006.

On Muhlenbergia glomerata. Smuggler's Notch, Aug. 1893 ; G. 370.

On Oryzopsis asperifolia. Richmond, Aug. 1898 ; H. 2008.

On Sporobolus serotinus. Newfane, Sept. 1892 ; G. 350.

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1 These species are placed by some authorities under the genus *Mycosphærella* Johans.

PHYLLACHORA OXALINA E. & E.

On Oxalis corniculata var. stricta. Johnson, Sept. 1893; G. In Herb. Ellis at Columbia.

PHYLLACHORA POMIGENA (Schw.) (*Dothidea pomigena* Schw.)

On fruit of Pyrus Malus, apple. Producing "Sooty mold." Burl., Sept. 1897; O. 2061.

[See foot note page 159 of this report.]

PHYLLACHORA TRIFOLII (Pers.) Fckl. (*Polythrincium Trifolii* Kze.)

On Trifolium hybridum, Alsike clover. Burl., Aug. 1897; O. 2002.
On Trifolium pratense, Red clover. Burl., Oct. 1890; C. 2003.
On Trifolium repens, White clover. Burl., Oct. 1898; H. 2734.
Common.

PLOWRIGHTIA MORBOSA (Schw) Sacc.

On branches of Prunus domestica, Plum. Burl., May, 1898; O. 2036.

On branches of Prunus sp. Plum. Charlotte, July, 1898; Waugh 2035. Brookline, Feb. 1899; O. 2227.

On branches of Prunus Cerasus, Cherry. Burl., Feb. 1999; O. 2330.

STIGMATEA ROBERTIANA Fr.

On Geranium Robertianum, Herb Robert. Burl., Oct. 1890; O. 2457.

VALSA AMBIENS (Pers.) Fr.

On dead branches of Fagus ferruginea, Beech. Johnson, April, 1895; G. 363.

On dead branches of Pyrus Malus, Apple. Johnson, G. 728.

VALSA NIVEA (Hoffm.) Fr.

On branches of Populus tremuloides, Poplar. Johnson, June, 1895; G. 364. Burl., Sept. 1898; O. 2001.

VALSA QUARTERNATA (Pers.) Fr.

On branches of Acer rubrum, Red maple. Johnson, April, 1895; G. 365.

XYLARIA CORNIFORMIS Fr.

On a decaying log, Smugglers' Notch, Sept. 1897; J. 2145.

XYLARIA DIGITATA L.

On a decaying log of Fagus ferruginea, Beech. Smugglers' Notch, Sept. 1897; J. 2146.

DISCOMYCETES[1]

CUDONIA CIRCINANS (Pers.) Fr.
On dead leaves. Burl., Aug. 1897 ; J. 2147.

LEOTIA LUBRICATA Pers.
On the ground in wet places. Newfane, Aug. 1897 ; C. D. Howe ; 2141.

MITRULA VITELLINA (Bris.) Sacc. var. IRREGULARIS Pk.
On the ground. Mt. Mansfield, Sept. 1897 ; J. 2150.

MORCHELLA ANGUSTICEPS Pk.
On the ground. Williamstown, May, 1897 ; L. B. Roberts, 2151. Burl. May, 1898 ; J.

MORCHELLA ESCULENTA Pers.
On the ground. Burl., May, 1897, J. 2152.

PEZIZA DEHNII Rab.
On stems and petioles of living Potentilla argentea, Cinquefoil. Burl., June, 1897 ; O. 2054. This fungus causes the plant attacked to become dwarfed and more bushy.

On stems and petioles of Potentilla Norvegica. Burl., July, 1898 ; H. 2057.

PEZIZA UNCISA Pk.
In wet moss on ledges. Newfane, Sept. 1897 ; C. D. Howe, 2062.

PSEUDOPEZIZA MEDICAGINIS (Lib.) Sacc.
On Medicago lupulina, Medick. Burl., July, 1898 ; H. 2058.
On Medicago sativa, Alfalfa. Burl., July, 1898 ; G. 2059.

RHYTISMA ACERINUM (Pers.) Fr.
On Acer dasycarpum, Silver maple. Burl., Oct. 1895 ; J. and O. 2044.

RHYTISMA ANDROMEDAE (Pers.) Fr.
On Kalmia glauca, Laurel. Stratton, July, 1895 ; J. 2045.

RHYTISMA ASTERIS Schw.
On Aster paniculatus. Burl., Oct. 1897 ; O. 2037.

RHYTISMA ILICIS-CANADENSIS Schw.
On Ilex verticillata, Winterberry. Beaver, Sept. 1897 ; O. 2046. Burl., July, 1898 ; O. 2048.

On Nemopanthes fascicularis, Holly. Stratton, Aug. 1892 ; G. 397 ; Belden Pond, Sept. 1894 ; G. 396. Johnson, Sept. 1894 ; G. 688. Burl., July, 1898 ; O. 2047.

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1 See also Vermont Helvelleæ, with descriptive notes. E. A. Burt. Rhodora 1, p. 59 (1899).

RHYTISMA PUNCTATUM (Pers.) Fr.

On Acer Pennsylvanicum, Striped maple. Burl., Oct. 1897; O. 2039.

On Acer spicatum, Mountain maple. Burl., Aug. 1892; J. 2041. Newfane, Sept. 1892; G. 394. Beaver, Sept. 1897; O. 2038. Walden, Aug. 1898; O. 2040.

RHYTISMA SALICINUM (Pers.) Fr.

On Salix cordata, Willow. Burl., Oct. 1897; O. 2050. Beaver, Sept. 1897; O. 2049.

RHYTISMA SOLIDAGINIS Schw.

On Solidago lanceolata, Golden-rod. Strafford, July, 1891; C. 2052. Newfane, Aug. 1892; G. 393.

SPATHULARIA CLAVATA (Schaeff.) Sacc.

On moist soil, Newfane, July, 1897. C. D. Howe, 2154.

SPATHULARIA FLAVIDA Pers.

On soil, Middlebury. Burt. 2155.

[1] HYMENOMYCETEÆ

EXOBASIDIUM VACCINII (Fckl.) Wor.

On Arctostaphylos Uva-Ursi, Bearberry. Snake Mt., July, 1898; O. 2143.

On Cassandra calyculata. Burl., June, 1896; G. 2138. Snake Mt., July, 1898; O. 2137.

On Vaccinium Cxycoccus. Mt. Mansfield, Aug. 1898; J. 2141.

On Vaccinium vacillans, Blueberry. Burl., June, 1896; G. 2139. Snake Mt., July, 1898; O. 2142.

FUNGI IMPERFECTI

SPHAEROPSIDEÆ

ACTINONEMA ROSAE (Lib.) Fr.

On Rosa sp., Cultivated rose. Burl., Jan. 1894; J. 483. Charlotte, Sept. 1898; O. 2764.

ASCOCHYTA FAGOPYRI Bres.

On Fagopyrum esculentum, Buckwheat. Beaver, Sept. 1897; O. 2737.

Apparently different from *A. Fagopyri* Thüm., which was described earlier and would have precedence under the laws of priority.

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[1] The remaining genera of Hymenomycetes are not included here as they do not properly come into a list of this character and since Dr. E. A. Burt of Middlebury college has in preparation a full list of this group.

ASCOCHYTA RHEI E. & E.

On Rheum Rhaponticum Rhubarb. Burl., Sept. 1898; O. 2996.

CICINOBOLUS CESATII De By.

On Erysiphe Cichoracearum, on various hosts. Burl., Sept. 1897; O. 785.

CORNULARIA PERSICAE (Schw.) Sacc.

On branches of Prunus Pennsylvanica, Wild cherry. Johnson, Apr. 1895; G. 480.

DARLUCA FILUM (Biv.) Cast.

On Coleosporium Sonchi. Burl., Aug. 1896; G. 2348.

On Uromyces Junci. Newfane, Oct. 1892; G. 2940.

ENTOMOSPORIUM MACULATUM Lev.

On Pyrus communis, Pear. Burl., Sept. 1898; J. 2963.

On Pyrus Cydonia, Quince. Burl., Oct. 1890; C. 3003.

LEPTOTHYRIUM POMI (Mont. & Fr.) Sacc.

On fruit of Pyrus Malus, Apple. "Fly speck fungus." Burl., Oct. 1897; O. 2977.

PHYLLOSTICTA ACERICOLA C. & E.

On Acer rubrum, Red maple. Burl., July, 1897; O. 3014.

On Acer saccharinum, Sugar maple. Beaver, Sept. 1897; O. 3015.

PHYLLOSTICTA AMPELOPSIDIS E. & M.

On Ampelopsis quinquefolia, Woodbine. Burl., Aug. 1897; O. 2377.

PHYLLOSTICTA BETAE Oud.

On Beta vulgaris, Beet. Walden, Aug. 1898; O. 2979. Burl., Sept 1898; O. 2777.

PHYLLOSTICTA CORNICOLA (DC.) Rabh.

On Cornus alternifolia, Dogwood. Burl., Sept. 1897; O. 2717.

On Cornus circinata. Burl., Sept. 1897; O. 2718.

PHYLLOSTICTA CRUENTA (Fr.) Kx.

On Smilacina racemosa, False spikenard. Burl., July, 1898; O 2728.

On Smilacina stellata. Burl., Aug. 1897; O. 2769.

PHYLLOSTICTA DECIDUA E. & E.

On Mentha piperita, Peppermint. Burl., July, 1898; H. 2980.

PHYLLOSTICTA ELLISIANA Lamb. & Fautr.

On Anemone Virginiana, Anemone. Providence Island, June 1898; H. & O. 2981.

PHYLLOSTICTA FATISCENS Pk.

On Nymphaea odorata, Water lily. Burl., Aug. 1898; O. 3028.

PHYLLOSTICTA GAULTHERIAE E. & E.

On Gaultheria procumbens, Wintergreen. Burl., July, 1897 ; O. 2380.

PHYLLOSTICTA NESAEAE Pk.

On Decodon verticillaris. Burl., Aug. 1898 ; O. 2981.

PHYLLOSTICTA PYRINA Sacc.

On Pyrus Malus, Apple. Burl., Aug. 1897 ; O. 2371. Isle La Motte, Oct. 1897 : J. 3034.

PHYLLOSTICTA QUERCUS-RUBRAE W. R. Ger.

On Quercus rubra, Red oak. Charlotte, Sept. 1897 ; O. 2982.

PHYLLOSTICTA TINEA Sacc.

On Viburnum lantanoides, Hobble-bush. Newfane, Sept. 1892 ; G. 436. Stratton, Aug. 1894 : G. 484.

PHYLLOSTICTA ULMICOLA Sacc.

On Ulmus campestris, Elm. Burl., Aug. 1897 ; O. 2982.

PHYLLOSTICTA VARIABILIS Pk.

On Rubus odoratus, Flowering raspberry. No. Calais, Aug. 1898 ; O. 2710.

PIGGOTIA FRAXINI B. & C.

On Fraxinus pubescens, Red ash. Newfane, Sept. 1892 ; G. 2012. Beaver, Sept. 1897 ; O. 2011.

SEPTORIA ACERINA Pk.

On Acer Pennsylvanicum, Striped maple. Newfane, Aug. 1892 ; G. 593. Burl., Aug. 1897 ; O. 2385. Beaver, Sept. 1897 ; O. 2375. Snake Mt., July, 1898 ; J. 2724.

SEPTORIA ANEMONES Desm.

On Anemone Virginiana. Providence Island, June, 1898 ; H. and O. 2987.

SEPTORIA AQUILEGIAE Penz. & Sacc.

On Aquilegia Canadensis, Honeysuckle. Burl., June, 1896 ; G. 2382.

SEPTORIA ASTRAGALI Desm.

On Lathyrus maritimus, Beach pea. Burl., Sept. 1898 ; O. 2791.

SEPTORIA ATROPURPUREA Pk.

On Aster cordifolius. Newfane, Aug. 1892 ; G. 454.

SEPTORIA BETULICOLA Pk.

On Betula lenta, Sweet birch. Burl., July, 1897 ; O. 3038.

On Betula populifolia, White birch. Burl., July, 1897 ; O. 2988.

SEPTORIA BRUNELLAE E. & H.

On Brunella vulgaris, Self heal. Burl., Aug. 1897 ; O. 2989.

SEPTORIA BRUNNEOLA (Fr.) Niessl.

On Smilacina racemosa, False spikenard. Burl., Sept. 1897; O. 3012.

SEPTORIA CHRYSANTHEMI Allesch.

On Chrysanthemum Leucanthemum, White daisy. Burl., Aug. 1897; O. 3025. Manchester, Sept. 1898; J. 3026.

This is apparently distinct from the species distributed by Cavara as *Septoria Chrysanthemi*, and which Saccordo lists under the name *S. Chrysanthemella* Cav., and also from *Septoria Chrysanthemi* Halsted.

SEPTORIA CIRSII Niessl.

On Cnicus arvensis, Canada thistle. Walden, Aug. 1898; O. 2722.

SEPTORIA CONSPICUA E. & M.

On Steironema ciliatum. Johnson, July, 1893; G. 472. Beaver, Sept. 1897; O. 2342.

SEPTORIA COPTIDIS B. & C.

On Coptis trifolia, Goldthread. Burl., June, 1898; O. 2743.

SEPTORIA CONVOLVULI Desm.

On Convolvulus sepium, Hedge bindweed. Burl., July, 1898; O. 2990.

SEPTORIA CORNICOLA Desm.

On Cornus alternifolia, Dogwood. Mt. Mansfield, June, 1897; O. 2707. Beaver, Aug. 1897; O. 2715. Manchester, Sept. 1898; J. 2802.

SEPTORIA CORYLINA Pk.

On Corylus rostrata, Hazelnut. Walden, Aug. 1898; O. 3037.

SEPTORIA CUCURBITACEARUM Sacc.

On Cucumis Melo, Muskmelon. Burl., Sept. 1898; J. 3024.

SEPTORIA DALIBARDAE Pk.

On Dalibarda repens. Burl., Aug. 1897; O. 2740.

SEPTORIA DIANTHI Desm.

On Dianthus caryophyllus, Carnation. Burl., Dec. 1892; J. 460.

SEPTORIA DIVARICATA E. & E.

On Phlox paniculata, Phlox. Burl., Sept. 1898; O. 2990.

SEPTORIA EPILOBII West.

On Epilobium adenocaulon, Willow-herb. Burl., Aug. 1898; O. & H. 2746.

SEPTORIA FAIRMANI E. & E.

On Althæa rosea, Hollyhock. Charlotte, Aug. 1897; O. 2366. Quite injurious to young plants.

SEPTORIA GALEOPSIDIS West.

On Galeopsis Tetrahit, Hemp Nettle. Johnson, Sept. 1894; G. 474. Burl., July, 1898; O. 2779. No. Calais, Aug. 1898; O. 2713.

SEPTORIA GEI Rob. & Desm.

On Geum macrophyllum, Avens. Walden, Aug., 1898; O. 2991.

SEPTORIA HIPPOCASTANI Berk & Br.

On Aesculus Hippocastanum, Horsechestnut. North Hero, Sept. 1897: J. 2351.

SEPTORIA INCRESCENS Pk.

On Trientalis Americana. Star flower. Burl., Aug. 1897; O. 2340.

SEPTORIA LEPTOSTACHYÆ E. & K.

On Phryma Leptostachya, Lopseed. Newfane, July, 1894; G. 477.

SEPTORIA LOBELIÆ Pk.

On Lobelia cardinalis, Cardinal flower. Charlotte, Aug. 1897; O. 2379.

SEPTORIA LYCOPERSICI Speg.

On Lycopersicum esculentum, Tomato. Burl., Sept. 1898; O. 2466.

SEPTORIA MALVICOLA E. & M.

On Malva rotundifolia, Mallow. Burl., Oct. 1890; G. 2462. North Calais, Aug. 1898; O. 2714.

SEPTORIA MUSIVA Pk.

On Populus monilifera, Cottonwood. Burl., Aug. 1897; O. 2460.

SEPTORIA NABALI B. & C.

On Prenanthes sp., Rattlesnake root. Mt. Mansfield, June, 1897; O. 2794.

SEPTORIA ŒNOTHERÆ West.

On Œnothera biennis, Evening primrose. Burl., Aug. 1890; J. 2468. Johnson, July, 1893; G. 476.

On Œnothera Oakesiana, Burl., Aug. 1898; H. 2386.

On Œnothera pumila. Burl., Aug. 1897; O. 2386.

SEPTORIA PISI West.

On Pisum sativum, Pea. Burl., July, 1898; J. 2770.

SEPTORIA POLYGÓNORUM Desm.

On Polygonum dumetorum var. scandens, Climbing false buckwheat. Beaver, Sept. 1897; O. 2992.

On Polygonum Persicaria, Smartweed. Burl., July, 1897; O. 2706. Beaver, Sept. 1897; O. 2368.

SEPTORIA POPULICOLA Pk.

On Populus balsamifera, Balm of Gilead. Providence Island, June, 1898 ; O. 2720.

SEPTORIA RHOINA B. & C.

On Rhus glabra, Sumach. Burl., Aug. 1897 ; O. 2384.

On Rhus typhina. Johnson, Sept. 1894 ; G. 705.

SEPTORIA RIBIS Desm.

On Ribes nigrum, Black currant. Burl., Aug. 1897 ; O. 2341.

On Ribes prostratum. Fetid currant. Mt. Mansfield, Aug. 1898 ; J. 2747.

On Ribes rubrum, Red currant. Underhill, July, 1898 ; J. 2745, Walden, Aug. 1898 ; O. 2721.

SEPTORIA RUBI West.

On Rubus hispidus, Swamp blackberry. Burl., July, 1897 ; O. 2369.

On Rubus occidentalis, Black raspberry. South Hero, Nov. 1897 ; O. 2463.

On Rubus villosus, Blackberry. Newfane, Aug. 1892 ; G. 469. Burl., Oct. 1896 ; G. 2324. North Calais, Aug. 1890 ; O. 2711.

SEPTORIA SACCHARINI E. & E.

On Acer saccharinum, Sugar maple. Newfane, Aug. 1892 ; G. 471. Walden, Aug. 1898 ; O. 2723.

SEPTORIA SAMBUCINA Pk.

On Sambucus Canadensis, Elderberry. Beaver, Sept. 1797 ; O. 2709.

SEPTORIA SEDI West.

On Sedum Telephium, Liveforever. North Calais, Aug. 1898 ; O. 3027. Abundant and destructive to this weed. Observed at Burlington and various other localities in Vermont. Probably occurs commonly on this host throughout the state.

SEPTORIA SMILACINÆ E. & M.

On Smilacina racemosa, False spikenard. Burl., Aug. 1890 ; J. 2482.

SEPTORIA TRILLII Pk.

On Trillium grandiflorum, Trillium. Burl., June, 1897 ; O. 2708.

SEPTORIA VERBASCICOLA B. & C.

On Verbascum Blattaria, Moth mullein. East Dorset, Aug. 1894 ; G. 703.

SEPTORIA VERBENÆ Rob. & Desm.

On Verbena hastata, Blue vervain. Burl., July, 1896 ; O. 2374. Beaver, Sept. 1897 ; O. 2349.

On Verbena urticæfolia, White vervain. Burl., Aug. 1887 ; O. 2373.

SEPTORIA VIOLÆ West.

On Viola blanda, Violet. Beaver, Sept. 1897 ; O. 2378. Underhill, July, 1898 ; J. 2719.

On Viola canina var. Muhlenbergii. Burl., 1897 ; O. 2730.

On Viola lanceolata. Vernon, July, 1895 ; G. 475.

SEPTORIA VIRIDI-TINGENS Curt.

On Allium tricoccum, Wild leek. Smugglers' Notch, June, 1895 ; J. 2469.

SEPTORIA WALDSTEINIÆ Pk. & Cl.

On Waldsteinia fragarioides, Barren strawberry. Charlotte, Sept. 1897 ; O. 2773. Burl., May, 1898 ; O. 2726.

SEPTORIA WILSONI Cl.

On Chelone glabra, Snake-head. Stratton, Aug. 1894 ; G. 701. Burl., Sept. 1896 ; G. 2383. Beaver, Aug. 1897 ; O. 2636.

STAGONOSPORA EQUISETI Fautr.

On Equisetum limosum, Scouring rush. Burl., Sept. 1898 ; O. 3031.

VERMICULARIA COPTINA Pk.

On Coptis trifolia, Goldthread. Burl., Aug. 1897 ; O. 2739.

VERMICULARIA PECKII var. VIOLÆ-ROTUNDIFOLIÆ Sacc.

On Viola rotundifolia, Violet. Johnson, June, 1895 ; J. 2474.

VERMICULARIA SUBEFFIGURATA Schw.

On Tragopogon porrifolius, Salsify. Johnson, Oct. 1894 ; G. 481.

MELANCONIEÆ

COLLETOTRICHUM LAGENARIUM (Pass.) Ell. & Hals.

On fruit of Cucumis Melo, Muskmelon. Burl., Sept. 1806 ; G. 2935.

COLLETOTRICHUM LINDEMUTHIANUM (Sacc. & Mag.) Scrib.

On Phaseolus vulgaris, Bean. Burl., 1892 ; J. 2937.

On Pisum sativum, Pea. Beaver, Sept. 1897 ; O. 2354.

CYLINDROSPORIUM PADI Karst. (*Septoria cerasina* Pk.)

On Prunus serotina, Black cherry. Newfane, Sept. 1892.

On Prunus sp., Cultivated cherry. Pittsford, July, 1896 ; J. 507.

On Prunus Armeniaca, Apricot. Colchester, Aug. 1896 ; G. 3002.

On Prunus sp., Plum. Burl., Sept. 1898 ; O. 3030.

CYLINDROSPORIUM SACCHARINUM E. & E.

On Acer rubrum, Red Maple. Stratton, 1894 ; G. 508.

CYLINDROSPORIUM TOXICODENDRI (Curt.) E. & E. (*Septoria Toxicodendri* Curt.)

On Rhus Toxicodendron, Poison ivy. Burl., July, 1898 ; O. 2741.

GLOEOSPORIUM ACERINUM West.

On keys of Acer Pennsylvanicum, Striped maple. Belden Pond, Sept. 1894; G. 2973. (Var. *fructigenum* E. & E.)

GLOEOSPORIUM BOREALE E. & E.

On Salix cordata, Willow. Johnson, Sept. 1894; G. 632.

On Salix sp. Newfane, Sept. 1892; G. 490.

GLOEOSPORIUM CORYLI (Desm.) Sacc.

On Corylus rostrata, Hazelnut. Burl., Aug. 1897; O. 3035.

GLOEOSPORIUM RIBIS (Lib.) Mont. & Desm.

On Ribes rubrum, Red currant. Burl., Aug. 1896; G. 3016.

GLOEOSPORIUM VENETUM Speg.

On Rubus strigosus. Red raspberry. Burl., Aug. 1890; J. 2974.

MARSONIA JUGLANDIS (Lib.) Sacc.

On Juglans cinerea, Butternut. Johnson, Sept. 1893; G. 510.

HYPHOMYCETEÆ

ALTERNARIA FASCICULATA (C. & E.) Jones & Grout (*Macrosporium chartarum* Pk. (Not Preuss.); *M. fasciculatum* C. & E.; *M. Maydis* C. & E.; *M. Tomato* Cooke. See Bul. Torr. Bot. Club, 24, pp. 254-258, 1897).

On Allium Cepa, Onion. Milton, Sept. 1896; Herrick, 265.

On Asclepias incarnata, Swamp milkweed. Burl., Oct. 1895; G. 2911.

On Asparagus officinale, Asparagus. Burl., Oct. 1897; O. 2332.

On Aster sp., Cultivated aster. Burl., Sept. 1896; G. 2999.

On Avena sativa, Oat. Burl., Aug. 1896; G. 380.

On Brassica alba, Mustard. Burl., Sept. 1896; G. 2910.

On Brassica oleracea, Cabbage. Burl., Aug. 1896; G. 382.

On Dahlia variabilis, Dahlia. Burl., Sept. 1898; O. 2480.

On Fagopyrum esculentum, Buckwheat. Burl., Sept. 1892; G. 2903.

On Gladiolus sp., Cultivated gladiolus. Charlotte, Sept. 1897; O. 3018.

On Lathyrus palustris. Gardener's Island, Aug. 1896; G. 431.

On Lycopersicum esculentum, Tomato. Burl., Sep. 1892; Tracy, 2905.

On old pasteboard exposed to the weather. Milton, Aug. 1896; G. 2904.

On Phaseolus vulgaris, Bean. Burl., July, 1896; G. 296.

On Raphanus sativus, Radish. Burl., Aug. 1896; S. 2909.

On Solanum tuberosum, Potato. Bradford, July, 1893; Tracy, 2914. Burl., Aug. 1894; Tracy, 2915. Dorset, Aug. 1895; Tracy, 2913.

On Zea Mays, Indian corn. Burl., Aug. 1896. G. 381.

ALTERNARIA SOLANI (E. & M.) Jones and Grout. (*Alternaria Solani* Sorauer in part; *Macrosporium Solani* E. & M.)

On Datura Tatula, Jamestown weed. Manchester, Sept. 1898; J. 2481.

On Lycopersicum esculentum, Tomato. Burl., Sept. 1896; G. 3000.

On Solanum tuberosum, Potato. Burl., Aug. 1892; J. 2921. Barton, Aug. 1892; J. 385. Pownal, Aug. 1892; J. 384.

BOTRYTIS VULGARIS Fr.

On Dianthus caryophyllus, Carnation. Burl., Jan. 1892; J. 276.

On Erythronium Americanum. Johnson, May, 1895; G. 263.

On Lactuca sativa, Lettuce. Burl., Jan. 1893; J. 264.

On Lilium Canadense. Johnson, July, 1893; G. 511.

BOTRYTIS sp., (the lily botrytis of Marshall Ward, Ann. Bot. 2; pp. 319-382, 1888-89.)

On Lilium candidum, Lily. Burl. July, 1896; J. & G. 326.

On Lilium speciosum. Charlotte, Sept. 1897; O. 2997.

On Lilium tigrinum. Charlotte, Sept. 1897; O. 2998.

CERCOSPORA AMPELOPSIDIS Pk.

On Ampelopsis quinquefolia, Woodbine. Burl., Aug. 1897; O. 2772.

CERCOSPORA APII Fr.

On Apium graveolens, Celery. Burl., Aug. 1894; J. 2461.

CERCOSPORA BETICOLA Sacc.

On Beta vulgaris, Beet. Burl., Oct. 1890; C. 2467.

CERCOSPORA CAULOPHYLLI Pk.

On Caulophyllum thalictroides. Johnson, Aug. 1893; G. 272.

CERCOSPORA CIRCUMSCISSA Sacc.

On Prunus serotina, Black cherry. Newfane, Sept. 1892; G. 2928.

On Prunus Virginiana, Choke cherry. Burl., July, 1898; O. 2929. Walden, Aug. 1898; O. 2930.

CERCOSPORA CLAVATA (Ger.) Pk.

On Asclepias Cornuti, Milkweed. Burl., Aug. 1890; J. 3006.

CERCOSPORA DUBIA (Riess.) Wint.

On Chenopodium album, Pigweed. Burl., Aug. 1892; J. 2793.

CERCOSPORA GRANULIFORMIS Ell. & Holw.

On Viola palmata var. cucullata, Violet. Burl., Aug. 1892; J. 2476.

On Viola pubescens. Burl., Aug. 1890; J. 2477.

CERCOSPORA MALI E. & E.

On Pyrus Malus, Apple. Burl., Aug. 1891 ; J. 2473. Walden, Aug. 1898 ; O. 2781.

CERCOSPORA MICROSORA Sacc.

On Tilia Americana, Basswood. Providence Island, June, 1898 ; O. 2931. Snake Mountain, July, 1898 ; O. 2932.

CERCOSPORA SAGITTARIÆ E. & K.

On Sagittaria variabilis, Arrowhead. West Townshend, Aug. 1894 ; G. 617.

CERCOSPORA SQALIDULA Pk.

On Clematis Virginiana, Virgin's bower. Newfane, Sept. 1892 ; G. 2333. Beaver, Aug. 1897 ; O. 2335.

CERCOSPORA VIOLÆ Sacc.

On Viola sp., Cultivated violet. Burl., Sept. 1898 ; O. 2800.

CERCOSPORELLA CANA (Pass.) Sacc.

On Erigeron annuus, Daisy fleabane, Isle La Motte, Oct. 1898 ; O. 3007.

CLADOSPORIUM FULVUM Cke.

On Lycopersicum esculentum, Tomato. Burl., Jan. 1893 ; J. 275. Injurious in the greenhouse.

On Solanum tuberosum, Potato. Burl., July, 1893 ; J. 2934. Dorset, July, 1894 ; Tracy, 2933.

CLADOSPORIUM HERBARUM (Pers.) Lk.

On Populus tremuloides, Poplar. Newfane, Sept. 1892 ; G. 288.

On dead wood of Tilia Americana, Basswood. Johnson, June, 1895 ; G. 274.

CLADOSPORIUM RAMULOSUM Desm.

On Populus tremuloides, Poplar. Burl., Aug. 1897 ; O. 2483.

FUSICLADIUM DENDRICTICUM (Wallr.) Fckl.

On Pyrus Malus, Apple. Burl., Sept. 1894 ; J. 2968. Isle La Motte, Oct. 1898 ; O. 2967. Walden, Aug. 1898 ; O. 2782.

FUSICLADIUM DEPRESSUM (B. & Br.) Sacc.

On Angelica atropurpurea. Johnson, Sept. 1893 ; G. 2970.

FUSICLADIUM PYRINUM (Lib.) Fckl.

On leaves and fruit of Pyrus communis, Pear. No. Calais, Aug. 1898 ; O. 2971. Burl., Sept. 1898 ; O. 2972.

HETEROSPORIUM GRACILE (Wallr.) Sacc.

On Belamcanda Chinensis, Blackberry lily. Charlotte, July, 1896 ; G. 299.

On Iris sp., Cultivated iris. Charlotte, Sept. 1897 ; O. 2975. Burl., Sept. 1898 ; O. 2976.

MACROSPORIUM PORRI Ell.

On Allium Cepa, Onion. Milton, June, 1896 ; G. 2979.

MACROSPORIUM SARCINULA Berk. var. PARASITICUM Thüm.

On Allium Cepa, Onion. Milton, Sept. 1896 ; Herrick, 301.

MICROSTROMA JUGLANDIS (Berang.) Sacc.

On Carya alba, Shellbark hickory. Burl., July, 1897 ; O. 2796.

MONILIA FRUCTIGENA Pers.

On Prunus domestica, Plum. So. Hero, Oct. 1898 ; O. 3005.

OVULARIA SOMMERI (Eichelbaum) Sacc.

On young stems of Myrica Gale, Sweet gale. Burl., May, 1897 ; J. & O. 2736.

PENICILLIUM GLAUCUM Grev.

On fruit of Pyrus Malus, Apple. Burl., Jan. 1892 ; J. 376.

PIRICULARIA GRISEA (Cke.) Sacc.

On Setaria glauca, Pigeon grass. Burl., July, 1897 ; O. 3008.

RAMULARIA ACTEÆ E. & H.

On Actea alba, White baneberry. Newfane, June, 1892 ; G. 308.

RAMULARIA ARMORACIAE Fckl.

On Nasturtium Armoracia, Horseradish. Milton, Sept. 1896 ; G. 3023.

RAMULARIA ARVENSIS Sacc.

On Potentilla Norvegica, Cinquefoil. Burl., June, 1898 ; O. 2727.

RAMULARIA CELASTRI Pk.

On Celastrus scandens, Bittersweet. Newfane, Sept. 1895 ; G. 310. Burl., Aug. 1897 ; O. 2370. No. Calais, Aug. 1898 ; O. 2712.

RAMULARIA DECIPIENS E. & E.

On Rumex crispus. Dock. Burl., Aug. 1897 ; O. 2986.

RAMULARIA IMPATIENTIS Pk.

On Impatiens fulva, Jewel weed, Beaver, Aug. 1897 ; O. 2797.

RAMULARIA NEMOPANTHES Pk.

On Nemopanthes fascicularis. Burl., July, 1898 ; O. 3020.

RAMULARIA OXALIDIS Farl.

On Oxalis acetosella, Woodsorrel. Stratton, July, 1894 ; G. 692.

RAMULARIA PLANTAGINIS E. & M.

On Plantago major, Plantain. Stratton, Aug. 1894 ; G. 691.

RAMULARIA RANUNCULI Pk.

On Ranunculus acris, Buttercup. Walden, Aug. 1898, O. 3019.

RAMULARIA RUDBECKIAE Pk.
On Rudbeckia laciniata, Cone-flower. Vernon, Aug. 1895 ; G. 690.

RAMULARIA TARAXACI Karst.
On Taraxacum officinale, Dandelion. Burl., July, 1897 ; O. 3013.

RAMULARIA URTICAE Ces.
On Urtica gracilis, Nettle. Burl., Sept. 1897 ; O. 2795.

SCOLECOTRICHUM GRAMINIS Fckl.
On Dactylis glomerata, Orchard grass. Burl., Sept. 1896. G. 3011.

KILLING WEEDS WITH CHEMICALS

Since the publication in a recent bulletin[1] of the successful results from the use of salt in killing the orange hawkweed many inquiries have been received as to the possibility of destroying a variety of other weeds with chemical agents.

The great difficulty in the practical use of chemicals as weed killers is in managing to kill the weeds without either destroying neighboring useful plants or leaving the soil so impregnated with the chemical as to interfere with the growth of useful plants thereafter. These difficulties interfere with the general usefulness of chemicals as weed destroyers. There are two cases where chemicals may be resorted to in spite of them. First, where an especially dangerous or obnoxious weed occurs in a limited locality and it is desired to destroy it quickly and utterly ; and, second, where the soil to be freed from weeds is not thereafter to be used for the growth of other plants, as in the case of gravel walks and roads, or those paved loosely with stone or wooden blocks, and also in tennis courts and similar areas.

Since numerous inquiries have concerned such cases it was decided to make a comparative test of a number of chemicals for these purposes. These tests have included the following: common salt, copper sulphate, sulphide of potassium, kerosene, arseniate of soda, and a mixture of white arsenic and sal soda, in addition to two proprietary articles described later. The details of this work were carried out at this station by Messrs. T. E. Hazen, a graduate student in its employ, and A. W. Edson.

The chemicals were tested by marking off areas in gravel walks, roadways, tennis courts and similar dry beaten soils, noting the character of the weed growth and observing the effect upon this of the applications of various chemicals. These applications were begun about July 1st and observations continued until autumn. In some cases the walks were occupied by weeds of considerable size, in others they had recently been hoed and raked over. The solutions were applied in all cases with an ordinary water-

1. Vt. Exp. Sta. Bul. 56, (1897.)

ing pot. It was found by experience that about eight gallons of solution was required effectively to wet down one square rod of such soil and that amount was used in most of this work. The results may best be presented topically as follows:

Nature of the weeds.—The knot-weed or knot-grass (*Polygonum aviculare* Linn.) was the most troublesome weed in the areas under observation. White clover and several of the annual grasses occurred commonly also (setarias and panicums especially) and in certain of the plots the perennial grasses, Kentucky blue and quack (*Agropyron repens*) were abundant. Purslane, plantains, blue-curls, dandelion and some other weeds occurred in some of the plots. Of these the knot-weed was distinctly the most troublesome, and the efficaciousness of a chemical in destroying this was considered the best gage of its value.

SALT

Common salt, sodium chloride, was tried upon gravel containing the knot-grass (Polygonum aviculare) and some of the coarser grasses (panicums, etc.) It was applied dry in amounts varying from four to twenty pounds per square rod, and in one case it was used in a larger but unmeasured quantity. It was found to be slow and imperfect in its action as a weed killer under these circumstances. Moreover, it washed into the grass borders and injured them considerably in case of rains. We are led to decide for these reasons that salt is not to be recommended for such weed killing. It has heretofore been shown that salt has a distinct practical value for killing the orange hawkweed, and that the larger of the amounts cited above is sufficient to eradicate that weed. There may be exceptional circumstances when the use of salt on roadways may be wise. Thus the superintendent of the Boston parks writes us that he obtains refuse salt at $1.00 per ton, which he uses freely and successfully on such of their roadways as permit of no danger to adjacent lawns or trees. True[1] finds that salt has slight toxic (poisonous) effects upon some plants, but most of its value as a weed killer depends upon the fact that it rapidly draws the water out of plant tissues with which it comes in contact. It is more effective, therefore, when applied dry (not as a brine) and also when applied on a dry, hot, sunshiny day.

COPPER SULPHATE

Copper sulphate or blue vitrol has been recommended as a weed killer,[2] and we began these experiments with the idea that it possessed considerable value for this purpose. Three strengths of solution were tried: one

1 True, Am. Assn. Adv. Sci., Proc. 47, p. 410 (1898).

2 Canada Exp. Farms, Bul. 28, p. 9 (1897).

pound in three gallons of water (4% solution); 1 pound in one and one-half gallons of water (8% solution); and one pound in one gallon of water (12% solution). In no case was the result satisfactory. For example, in one plot containing plantain, purslane and various grasses the results following the application of a 5% solution were as follows: At at the end of one week some of the purslane leaves were dead, but no plants entirely killed. The purslane and grass leaves were but slightly affected. At the end of two months most of these plants had recovered their vigor. All our trials agree in showing that copper sulphate is inferior as a weed killer to other chemicals to be mentioned later. It is worthy of note in this connection, however, that copper sulphate may have decided value as a weed-killer under other circumstances. It has been found by recent trials in Europe that a weak solution of this chemical sprayed over a grain field infested with kale may destroy the weed without injuring the grain. H. L. Bolley of the North Dakota experiment station writes that experiments made by him indicate that it is possible to destroy the common annual weeds in a grain field by such use of a 3% solution and that this strength does not injure the grain. In the light of our own experiments we are led to believe it probable that such results as he describes are due to the killing by the solution of the tender upper portions of the weed plants. The grain in its rapid growth would soon overtop and smother the weeds thus weakened.

Further investigations of the practical usefulness of this chemical as a weed killer may therefore be awaited with interest.

KEROSENE

This was used diluted with water in the proportion of one part kerosene to three parts water (25% mixture). When so diluted and applied at the rate of 8 gallons to the square rod it failed to kill the weeds. It became evident, therefore, that the herbicidal activity of the kerosene is so slight in proportion to its cost as to preclude its practical use as a weed killer.

POTASSIUM SULPHIDE (LIVERS OF SULPHUR)

One pound in three gallons of water (4% solution) when applied at the rate of eight gallons per square rod, in one trial was not effective in destroying the weeds. It gave so little promise of practical value that no further trials were made.

CARBOLIC ACID

The crude liquid was added to water in proportions varying in different trials from one pint per gallon (12½% sol.) to one-fifth pint per gallon (2½% sol.). This was mixed with the water by agitation and was applied

in some cases hot, in others cold, at the rate of eight gallons per square rod. The results were generally satisfactory, with solutions stronger than 3%, that is, containing one-fourth pint or more to the gallon of water. This chemical was quicker in its action than was any other under trial. In twelve hours after its application all parts of the weeds above ground were browned and apparently killed. These weeds included plantain, dandelion, chicory, rag-weed and grasses. A week later they appeared the same. Two months later there was evidence of the survival and recovery of some of the plants. The dandelion roots had not been entirely killed and some new shoots were appearing. A large proportion of the grass (quack and Kentucky blue) had likewise thrown up new shoots, and some seedling weeds were growing which had germinated since the application. It was one of the best chemicals used for killing knot-grass.

These results indicate that carbolic acid is a valuable herbicide and very quick in its action, but that it does not penetrate deeply enough into the soil to destroy all of the underground parts of certain weeds and that the herbicidal action is of short duration as compared with some other chemicals. There are two objectionable features associated with the use of carbolic acid. First, its odor. This is strong and to many disagreeable, and renders its use in the immediate vicinity of a house somewhat objectionable. This odor disappears soon after the application is made. Second, the insolublility in water. It is of a heavy, oily nature and does not form a permanent mixture with water. It is necessary, therefore, to agitate it frequently while the application is being made in order to insure uniformity in the distribution.

WHITE ARSENIC AND SAL SODA MIXTURE

This was used in the manner suggested by Shutt,[1] viz : white arsenic, one pound ; washing soda, two pounds ; water, three to nine gallons. The weaker solution proved strong enough to destroy practically all weeds. The perennial grasses were the only plants which survived the applications and most of them were killed. It was not so quick in its action as was the carbolic acid, but its effects were more enduring. Some plots treated with it in July, 1898, were still practically free from weeds in August, 1899.

There are two objectionable features associated with the use of this mixture. First, the trouble of preparing it ; and, second, the fact that it is a deadly poison to animal life. Neither of these is so serious as to preclude its usefulness, but both need to be taken into consideration in estimating its practical merits as compared with other herbicides.

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1 Canada Exp. Farms, Bul. 28, p. 9, (1897).

ARSENIATE OF SODA

This is a chemical which is readily soluble in water. It was chosen as offering for this reason a convenient substitute for the mixture of sal soda and white arsenic. It was used at the rate of one pound in four gallons of water, and also of one pound in eight gallons of water. The latter strength proved sufficient to destroy practically all weeds. It was a little prompter in its action than was the preceding mixture, and, on the whole, was rather more effective. Its persistence in the soil seemed about equal to that of the arsenic and sal soda mixture. The objection holds against this also that it is an active poison to animals. It is also somewhat more expensive than is the white arsenic and sal soda mixture, but for operations on a small scale its greater convenience serves to recommend it for use.

COMMERCIAL WEED KILLERS

In addition to these compounds, trial was made of two commercial weed killers. One of these was obtained from Peter Henderson & Company of New York, under the trade name of Herbicide. It was in the form of a liquid and put up in a one-gallon can. The cost was one dollar a can. The directions were to dilute this with twenty-five gallons of water. It was so diluted and applied like the other solutions, eight gallons to the square rod. It proved very effective, its action being similar to that of the preceding arsenical solutions. It was not as prompt in action as was the carbolic acid, but fully equal to any of the other chemicals tested. At the end of one week practically all the weeds, including the grasses, were apparently dead. At the end of two months these herbicide plots were considerably cleaner than were those treated with carbolic acid, and were in fully as good condition as were those treated with any other chemical under trial.

Chemical examination[1] showed this herbicide to contain much arsenic associated with an alkali. It is apparently very similar in composition to the arsenical solutions already discussed, and is of course open to the same objection as a poison. The cost of the diluted solution is four cents a gallon, which is considerably greater than that of the other arsenical solutions. This greater cost is to be weighed against its greater convenience as compared with some of the others.

Another preparation tested is that known as Smith's Perfect Weed Killer, sent out by Mark Smith, Louth, England. It is put upon the market in two forms. One of these is a concentrated liquid similar to the herbicide just discussed, the other is a dry powder. This latter is said to be the same thing as the liquid in a different form, and was used in our trials diluted with water according to directions. It behaved similarly to the arsenical solutions and the herbicide already discussed. Its action was

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1 See chemical analysis, p. 147.

rather slower than these during the first few days, but ultimately the results were practically alike.

COST OF THE VARIOUS CHEMICALS

It is evident from these results that it is possible to kill weeds by the use of chemicals. The practical usefulness of the method depends largely upon the expense. Two elements enter into this, first, the cost of the chemicals; and, second, the frequency with which the application must be repeated. The price of the chemicals will, of course, vary. The Burlington Drug Company recently gave us the following quotations on one hundred pound lots:

Crude carbolic acid, 25 cents a gallon.

Sal soda, 1¼ cents a gallon.

White arsenic, 6½ cents a pound.

Arseniate of soda, 11 cents a pound.

The cost of these as diluted and used in the proportions and amounts indicated in our experiments becomes as follows:

Crude carbolic acid.—1 pint in 4 gallons of water, or 4% solution, ½ cent a gallon or 4 cents a square rod.

Arsenic-sal soda mixture.—Weaker form, 1 cent a gallon or 8 cents a square rod.

Arseniate of soda.—1 pound in 8 gallons of water, 1½ cents a gallon or 11 cents a square rod.

Henderson's herbicide cost us $1.00 for the can, to be diluted to 25 gallons; cost of a gallon as used 4 cents, or 32 cents a square rod.

Smith's weed killer cost in England 43 cents a can (dry form) to be diluted to 25 gallons. Cost for a gallon about 2 cents, or 15 cents a square rod. The cost of the liquid form is practically the same. The duty and cost of carriage must of course be added to these prices. These additions would probably bring the cost of the english article to nearly that of the american.

The frequency with which it may be necessary to repeat the application of these weed killers is not fully decided by our experiments. Apparently, one thorough application each year would be sufficient of either of the arsenical solutions, or of the two proprietary compounds. It is doubtful if one application of carbolic acid would suffice, but two would quite certainly do so. It seems probable also that the effects of many of these arsenical applications will be cumulative owing to the retention of the poison in the soil. These conclusions are borne out by the experience of Prof. Nicholson of the Royal gardens, Kew, England, who writes us that the Smith's Perfect Weed Killer is used in the walks and drives of that institution and that one application yearly suffices.

GENERAL CONCLUSIONS

Gravel walks, drives, tennis courts and similar places can be kept free from weeds by the use of certain chemicals.

Common salt can be used for this purpose, but very heavy applications are required, and when used in such amounts it is liable to be washed into the borders of adjacent lawns. Salt should always be applied in the dry form. The weeds may be more fully suppressed without such danger from washing by certain other chemicals. These are to be applied in solutions, and at the rate of about eight gallons to the square rod.

Crude carbolic acid is a very powerful and quick acting herbicide. One pint in four gallons of water is usually sufficient, cost as diluted, ½ cent for a gallon, 4 cents to the square rod. Its effects are not as enduring, however, as are those of the arsenical solutions.

Various arsenical compounds are available, including arseniate of soda, a mixture of white arsenic and sal soda, and two proprietary articles. The choice between these latter becomes largely a matter of relative expense and convenience. In general, the choice should in our judgement lie beween the crude carbolic acid and the arseniate of soda.

One, or at most, two applications each season of one or another of these chemicals will, it is believed, suffice to keep down the weeds.

up to or above guaranty, one-seventh fell short somewhat, and one-twentieth failed to furnish a commercial equivalent of their guaranties.

2. *Quality of plant food furnished.*—While as a rule the quality of the crude stock used was good, there were some cases which seem open to criticism. Two-fifths of the brands carried no water-soluble nitrogen. There appears to have been somewhat inferior forms of nitrogen used in certain cases, notably in some low grade goods and by two companies, whose goods have been on this account open to some suspicion for three years. The phosphoric acid was in some cases quite largely in the insoluble or reverted forms, indicating apparently either much undissolved bone, imperfect manufacture, old goods, or more or less use of (agriculturally) inferior forms of this ingredient. Sulphate of potash is claimed to be present in three-fourths of the brands, but was actually found in but one-seventh.

3. *Selling prices and valuations.*—The average selling price approximated $28.73 and the average valuation, $18.08. Two dollars in every five paid for fertilizers met the costs of manufacture and sale. An amount of plant food which cost a dollar might have been bought at retail for cash at the seaboard for 58 cents in average low priced goods, for 63 cents in average medium grade brands, and for 68 cents in average high priced goods. In nearly one-fourth of the entire number of brands, a dollar was charged for amounts of plant food which might have been bought at retail in the larger markets for 55 cents or less. "Cheap fertilizers" are usually the most expensive.

V. *The average composition* of the brands sold is perhaps very slightly higher than last year. Selling prices have remained unchanged notwithstanding an advance in the price of crude stock. Plant foot is as cheap as it ever was ; yet buying mixed goods on time is still a more costly method of getting plant food than is home-mixing or buying on special order.

VI. *The comparison of analyses of 133 brands for five years* shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods.

REPORT OF THE BOTANIST

L. R. Jones

The investigations of this year have been conducted along the same lines as in previous years. The greater part of the time has been given to studies of plant diseases and their remedies. Investigations and observations have been made in addition upon weeds and herbicides or chemical weed-killers, impurities of grass and clover seeds, and various agricultural grasses and clovers. The experimental studies of maple sap pressure and flow have also been continued. In several of these subjects the work is still in progress and publication at this time is undesirable.

There was no regularly appointed assistant botanist during this year. Valuable aid was received, however, from two persons. Mr. Clifton D. Howe, a graduate student in botany, has attended to most of the details of the seed examinations and the report upon the impurities of grass and clover seed was prepared by him. Mr. A. W. Edson has had immediate charge of most of the experimental work in the field since July 1, 1899. Upon July 1, 1900, Mr. Edson was appointed assistant botanist for the ensuing year and in this capacity he has aided materially in preparing the present report for the press.

The subjects to be discussed are as follows:

- Potato diseases and their remedies.
  - I. Potato diseases as they occurred in 1899.
  - II. Results from spraying potatoes in 1899.
    - 1. Relative values of various compounds.
    - 2. Relative gains from spraying at different dates.
  - III. Experiments in the prevention of potato scab.
- Leaf-scorching of trees by the wind.
- Killing weeds with chemicals.
  - I. Sulphuric acid compared with salt for the orange hawkweed.
  - II. Killing kale with copper sulphate.
- Impurities of grass and clover seeds.
- A bacterial soft rot of carrots and other vegetables.

POTATO DISEASES AND THEIR REMEDIES

I. POTATO DISEASES AS THEY OCCURRED IN 1899

The season of 1899 was a dry one, but on the whole fairly favorable to the potato crop at Burlington. The yields were reduced by dry weather,

but as stated below, there was less disease than usual. The unsprayed plants of the vigorous later varieties, such as Rural New Yorker and White Star, lived well into September. By September 25 most of them were dead owing, however, to insect and physiological troubles rather than to fungus blights. The flea-beetle was, as in former years, a most serious pest, its destructive work on the plants being evident from July 25 to the close of the summer. Tip-burn appeared in the experimental plots about August 15, being relatively much worse on sandy soil than on heavier land. Spraying with bordeaux mixture was decidedly beneficial in warding off these troubles and thereby prolonging the life of the plant as is shown in the succeeding account. Plants protected by this spraying had a full month added to their effective development.

II. RESULTS FROM SPRAYING POTATOES IN 1899

1. RELATIVE VALUES OF VARIOUS COMPOUNDS

Experiments were planned in continuation of those of former years to determine the relative values of various fungicides and insecticides upon potatoes. In considering these results it should be borne in mind that there was no fungus blight on any of the sprayed or unsprayed plants. Had there been, the results might have been materially altered.

These trials included the following compounds:

Standard bordeaux-paris-green mixture.—One and one-half pounds copper sulphate, 1 pound lime, 2 ounces paris green, 10 gallons water. This is the mixture which, after ten years of experience, we have found best suited for general spraying. The method of preparing the mixture has been to make two stock solutions, one containing the copper sulphate dissolved in water at the rate of 1 pound of sulphate to 1 gallon of water; the other containing 1 pound of lime and 2 ounces of paris green, to each gallon of water. Much care is taken to slake the lime properly and thoroughly. These stock solutions are made at the beginning of the season and when it is desired to make up the bordeaux, the desired amount (four gallons) of the lime-paris-green water is put into the barrel of the spray pump, which holds about 45 gallons. While the barrel is being filled with water, the sulphate solution (6 gallons) is gradually added with frequent agitation of the whole. Everything that goes into the pump is passed through a fine brass strainer. In this way a uniform mixture of a bright blue color is secured, free from matter which might interfere with the operation of the pump or nozzles.

Bug death.—Light application, 2½ pounds to the acre.

Bug death.—Heavier application, 5 pounds to the acre, (on one plot it was applied at the rate of 60 pounds to the acre). Bug death is a fine powder and was applied by means of a "Perfection" shaker as directed by the

manufacturers. It was generally put on in the morning before the dew was off the plants.

Laurel green.—Light application, 1 pound to the acre.

Laurel green.—Heavier application, 2 pounds to the acre.

A Leggett powder gun was used in putting on this preparation. It was generally applied in the morning while the dew was on the plants.

Plaster and paris green.—One pound of paris green in 80 pounds of plaster and applied very heavily, at the rate of about 180 pounds an acre.

Two similar plots were planted on May 18 for experimental spraying. The soil was a fairly uniform heavy clay loam. Plot I was planted with White Star, plot II with Delaware. During the first part of the summer all the plants were poisoned alike with paris green in water as often as necessary, to protect them from the Colorado potato beetle. A similar application of paris green was made upon the check rows during the latter part of the summer at each time that the remainder of the rows were sprayed experimentally. The experimental applications were made on July 26, August 17 and September 8.

The method of treatment on the two plots I and II was the same, the rows on each being sprayed as follows:

Rows 1 and 2.	Check; paris green in water.
Rows 3 and 4.	Bug death; 2 to 3 pounds to the acre.
Rows 5 and 6.	Laurel green; 2 pounds to the acre.
Rows 7 and 8.	Bordeaux-paris-green mixture.
Rows 9 and 10.	Paris green; 3 pounds, gypsum 180 pounds to the acre.
Rows 11 and 12.	Check; Paris green in water.
Rows 13 and 14.	Bug death; 5 pounds to the acre.
Rows 15 and 16.	Laurel green; 1 pound to the acre.
Rows 17 and 18.	Check; Paris green in water.

From time to time observations were made upon the condition of the plants in different rows.

At the time of the first application and for nearly two weeks thereafter no difference could be distinguished in the condition of the several plots. All seemed to thrive alike. But by the time of the second application, August 17, marked differences showed themselves and from that time on these differences increased, as is indicated in the following paragraphs.

Bordeaux-paris-green mixture.—In all cases, the plants in the bordeaux rows were larger and more flourishing, with leaves larger and of a darker green color. Little evidence of work of either the Colorado beetles or the flea-beetles could be found upon them. Compared with the other rows, there was very little tip burn and new shoots continued to form upon these plants until the close of the season. It was only after the first frosts that the plants began to die and when the potatoes were dug (October 20) the stems were green with some green leaves.

Check rows.—These were visibly inferior to the bordeaux rows on August 17. There was considerable tip burn, more in some checks than others, and the work of the flea beetles was very noticeable. A week later, August 24, the check rows were plainly distinguishable from the others, having a brown color quite different from the dark green of the bordeaux rows. September 28 most of the plants were dead.

Paris-green-gypsum rows.—These appeared rather better than the check rows throughout the latter part of the season. There was somewhat less flea-beetle work upon them, but the amount of tip burn was very nearly the same.

Laurel green.—These rows were better than the check rows and appeared about the same as the paris-green-gypsum rows. Laurel-green was effective in destroying the Colorado potato beetle and it lessened the injury from the flea-beetle although it did not entirely prevent it. There was, however, serious burning of the foliage (arsenical poisoning) where this powder was used in the heavier amounts. The manufacturers promise to remedy this. Until this is done, it is hardly safe for use on potatoes.

Bug death.—The rows where this was used were kept in better condition than were any of the others in the field except the bordeaux rows. Bug death seemed to protect the plants against both the Colorado and the flea beetles. In one corner of the main potato field, trial was made of very heavy applications of Bug death, viz: 60 pounds an acre on each of the three dates of spraying. The results were that on these rows the vines were presèrved in just as healthy condition as were the adjoining rows which received the standard bordeaux-paris-green mixture. The amount of Bug death here used, a total of 180 pounds to an acre, is of course prohibited in field practice by its cost, but the results serve to show that Bug death has real virtues and also, that even in excessive amount it does not hurt the foliage.

The plots were dug October 20. The following table gives the results expressed in terms of bushels to the acre:

YIELDS FROM PLOTS SPRAYED EXPERIMENTALLY

Nature of application	Yields in bushels per acre		Average of the two plots
	Plot I White Star	Plot II Rural N. Y.	
Bordeaux-paris-green mixture	227	237	232
Check. Paris-green in water	166	168	167
Gypsum-paris-green mixture	179	189	184
Laurel green, 1 pound per acre	141	197	169
" " , 2 " " "	151	181	166
Bug death , 3 " " "	217	190	203
" " , 5 " " "	187	201	194

These results are especially significant when it is remembered that there was no fungus blight whatever upon any of the potatoes. Bordeaux mixture is used primarily as a fungicide but from the above returns, coupled with similar evidence of former years, it is clear that it is also a most valuable remedy against insect attacks. Moreover it stimulates more vigorous leaf development. It is regretted that we were again, as in 1898, left without a basis for judging of the relative merits of the various substances as fungicides. Upon this point there is no reasonable ground for doubt, however. Bordeaux mixture stands without an equal in this respect. We are therefore again led to state, as in every former trial, that the standard bordeaux paris-green mixture is far superior to any other substance as yet tested by us, for practical use as a combined insecticide and fungicide for potatoes. The amount of gain from the use of this mixture on the smaller scale on our experimental plots, was almost exactly duplicated upon the main potato field of the farm. This was a moist sandy loam, and the plants were sprayed three times. Some unsprayed rows were left in one corner of the field for comparison. The result was a yield of 150 bushels an acre from the unsprayed rows and of 223 bushels from the adjoining sprayed field.

Adding the average of these figures obtained in 1899 to those obtained during the previous eight seasons of experimental use of bordeaux mixture, we have the gratifying results shown in the following table. In the face of these figures, showing as they do an average gain of 117 bushels an acre in return for two or three applications of bordeaux mixture, it seems beyond question that the spraying of later potatoes should be generally practiced in Vermont.

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre		Gain per acre
			where sprayed	where not sprayed	
White star	May —, 1891	August 26, September 8	313 bu.	248 bu.	65 bu
" "	May 20, 1892	July 30, August 13, 25	291 "	99 "	192 "
" "	May 20, 1893	August 1, 16, 29	338 "	114 "	224 "
" "	Apr. 26, 1894	June 16, July 17, August 30	323 "	251 "	72 "
" "	May 20, 1895	July 25, August 13, 31	389 "	219 "	170 "
Polaris	May 15, 1896	August 7, 21	325 "	257 "	68 "
"	June 1, 1897	July 27, August 17, 28	151 "	80 "	71 "
White star	May 10, 1898	July 21, August 10	238 "	112 "	126 "
Ave. 3 vars	May 18, 1899	July 26, August 17, September 8	229 "	161 "	68 "
Average for past nine years			288 bu.	171 bu.	117 bu.

2. RELATIVE GAINS FROM SPRAYING AT DIFFERENT DATES

The number and dates of applications to secure the best results are matters which vary with the season. To determine the relative importance

of each of the three applications of bordeaux-paris-green mixture made in 1899, experiments were planned in which one or two of the applications were omitted. As already stated, the date of the first application was July 26, of the second August 17, and of the third September 8.

The effects of these omissions were judged in two ways, first by the appearance of the foliage upon the various rows, and second by their relative yields.

Careful comparisons of the appearance of the foliage from time to time led to the following conclusions :

1. The first application was the most important of the series. The rows which received this alone were better protected than were those which received both the second and third, but lacked the first.

2. The plants receiving the second application alone, or even the second and third together, looked but little better than the untreated plants.

3. The plants receiving the first and second applications were better protected than those receiving the first and third.

4. The application made at the third date upon plants which received the first and second applications, had a distinct value.

The above conclusions were nearly all borne out by the results obtained upon digging as shown by the following figures which represent the average yields from the various rows :

YIELDS FROM POTATO PLOTS SPRAYED AT DIFFERENT DATES

Applications made	Yields per acre
July 26, August 17, September 8	227 bushels
July 26, August 17	193 "
July 26, September 8	203 "
July 26	185 "
August 17, September 8	150 "
August 17	152 "
Check, not sprayed	134 "

From these results it is evident that the first application was the most important one, and that about one-half of the entire gain was attributable to that ; that the second and third were about equal in importance; and that each of them was profitable since it added 25 or more bushels an acre to the crop.

III. EXPERIMENTS IN THE PREVENTION OF POTATO SCAB

The fact has been clearly demonstrated that potato scab is a fungus disease.[1] It has further been shown that the germs of the disease may be carried upon seed potatoes, and also that the fungus may continue to exist in infected soil for at least several years, even if no potatoes are grown there during such period. The practical remedy for the disease, where the

1 Thaxter, R. Conn. Exp. Sta., Rpt. 14, p. 81 (1890).

soil is free from the fungus, consists, therefore, in the disinfection of the seed potatoes. Where the fungus already exists in the soil, the problem becomes more difficult.

Two chemical solutions have proved satisfactory disinfectants for use on the seed tubers—namely, corrosive sublimate,[1] and formalin.[2] Recently the use of sulphur has been advocated[3] and it has been hoped that the use of this might prevent the development of the disease, even in infected soils.

Comparative trials have been made at this station during previous years, which have led us to believe that both of the above solutions are practically effective as seed disinfectants, but for reasons of convenience and safety, we have been led to recommend the formalin solution. We have heretofore made no trial of sulphur. The present season (1900) we planned a more extensive series of plots than heretofore, aiming to secure evidence as to the value of sulphur upon infected soil, and also of some other methods of disinfection than those heretofore mentioned. For these experiments plots were laid out in three fields, as follows :

Field I. This was a very light sandy soil, selected for this experiment because it had but recently been cleared from timber, with no subsequent cropping, and was, therefore, presumed to be free from the germs of the scab fungus.

Field II. This was a sandy loam which had been manured well in previous years so that it was in excellent tilth for potatoes. No potatoes had been grown on it for at least seven years, and its condition as to soil infection was unknown, although it was feared there might be some germs in the soil.

Field III. This was a clay loam, rather heavy for the best quality of potatoes, but very productive. Potatoes grown upon it the previous season had scabbed badly and it was assumed that the scab fungus had persisted in the soil. It offered, therefore, an opportunity for testing the sulphur method for soil sterilization.

The seed potatoes used were of two varieties, Delaware and Rural New Yorker. Every tuber planted in Field I and Field II was more or less scabby. The Delawares had from one to a dozen well developed scab spots on each tuber, while the Rural New Yorkers were about as scabby as potatoes could be and grow.

In Field III, smooth tubers were used for all except one row. The details regarding each plot are given later.

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1 Bolley, H. L., N. D. Exp. Sta., Bul. 4 (1891).
2 Arthur, J. C. Ind. Exp. Sta., Bul. 65 (1897).
3 Halsted, B. D., N. J. Exp. Sta. Bul. 112 (1895).

Six methods looking to the disinfection of seed or soil, were tried upon one or another of these plots, as follows:

1. *Corrosive sublimate.*—1 ounce in 8 gallons of water; seed potatoes soaked 1½ hours in the solution. Part of the tubers treated two months before planting, and part treated one day previous to planting.

2. *Formalin.*—8 ounces in 15 gallons of water; seed potatoes soaked two hours in the solution. Part of tubers treated two months before planting, and part treated one day previous to planting.

3. *Formaldehyde gas.*—Commercial formalin is a gas, formic aldehyde, dissolved in water. This gas is of course the active agent. Various lamps are on the market for generating this gas for use in disinfecting rooms, etc., and it seemed possible that the use of this gas, instead of the liquid, for disinfecting tubers and seeds, might prove practicable. If so, it has certain manifest advantages over the former method of soaking the seed in disinfecting liquids. We tried this method, using Schering's formalin lamp.[1]

FIG. I. SCHERING FORMALIN LAMP

One-half a bushel of exceedingly scabby tubers destined for seed were placed in an air tight box having a capacity of 8 cubic feet. One-half of one of the pastilles or tablets (i. e. ½ gram) was heated in the lamp according to the directions given, and the box was kept closed for six hours thereafter.

4. *Sulphur.*—Halsted has found that rolling the seed tubers in sulphur and scattering the sulphur in the drill along with the seed checks the development of scab. This was done in our experiments using the flowers of sulphur at the rate of 300 pounds to the acre in fields I and II and 475 pounds to the acre in field III.

5. *Sulphur fumes.*—The disinfecting value of sulphur fumes for many purposes has long been recognized. The possibility of disinfecting seed-potatoes by sulphur fumes was, so far as we know, first suggested by J. C. Norton,[2] a Kansas potato grower who burned ½ teaspoonful of sulphur in his storage cellar, and believed that his seed potatoes were satisfactorily disinfected as a result. This method is so inexpensive and would prove so convenient for many potato-growers that it is worthy of careful trial by more exact methods than Mr. Norton used.

In our trial one-half bushel of very scabby tubers destined for seed were inclosed in a tight box containing eight cubic feet. One gram of

1 This lamp was obtained from Schering & Glatz, 55 Maiden Lane, New York City. It consists essentially of an alcohol lamp and a reservoir to receive the tablets which generate the formalin gas when heated. The outfit is very simple and is accompanied by full directions and a package of 40 of the 1 gram tablets or pastilles. Price, $1.75. See Fig. I.

2 Norton, J. C. A New Way of Preventing Scab, Rural New Yorker, Oct. 21, 1899. Mr. Norton states that his cellar was 32x20 feet inside, height not given, and contained 400 bushels of potatoes.

flowers of sulphur was burned in this box which was sealed air-tight immediately after igniting the sulphur and was left thus sealed for twenty-four hours. When opened, the sulphur was found to be practically all consumed and the air was heavily laden with the sulphurous gas.

6. *Insolation.*—Sunlight has well-known germicidal action. The possibility of destroying the germs of the scab upon the surface of seed potatoes by exposure to sunlight, was brought to our attention by Mr. D. C. Hicks of Clarendon, Vt., who says that he has been in the habit of thus exposing some of his seed potatoes in order to hasten growth, and that he has observed for several years the comparative freedom from scab of the crop from tubers so treated. For the purposes of our experiment scabby potatoes designed for seed for Field I were exposed upon a sunny shelf in the green-house for one month before planting (March 28 to April 24). They lay in a single layer and were turned over four times, about once a week, that all parts of the tuber might receive the direct light. They were benefited by this treatment as shown by the fact that these rows in Field I were up a week ahead of any of the others. Another lot designed for use in Field II, lay from March 28 till May 23. The sprouts on these developed too far and were thereby so weakened that they did not grow well after planting.

DETAILED ACCOUNT OF THE PLOTS AND RESULTS

Field I.—As already explained this was virgin sandy soil. It was considered to be entirely free from the scab germs and the results indicate that this supposition was correct. There were twenty-one rows each six rods long. The potatoes were planted April 24 and dug August 29. The rows were three and a half feet apart. Scabbed seed of the two varieties was used and in each case two adjacent rows were planted to seed which had been given the same preliminary treatment. The details of methods of treatment have been stated earlier. When dug each tuber was carefully examined for scab spots. The scabby potatoes in each row were separated from the clean ones and both lots were counted. None of these potatoes were very badly scabbed, probably because of the light soil and dry season, so that no attempt was made to sort them as to degree of scabbiness. The details as to arrangement of the rows and condition of the crop are given in the following table. It will be seen that rows where the method of disinfection was of doubtful efficacy were separated from the adjacent rows by non-experimental rows to avoid danger of cross infection between them. The irregularities in yield were due to stumps and other unavoidable conditions which need not in our judgment be considered in weighing the results. A more critical discussion of these results is made later in this article.

FIELD I. PLAN AND RESULTS

Row No.	Treatment of seed	Variety	Total No. of tubers	No. of clean tubers	No. of scabby tubers	Per cent scabby tubers	Averages
1	Corrosive sublimate	Delaware	451	430	21	4½	6
2	Corrosive sublimate	Delaware	458	425	33	7½	
3	Formalin	Delaware	435	410	24	5½	7¼
4	Formalin	Delaware	582	530	52	9	
5	Corrosive sublimate	Rural N. Y.	366	360	6	1⅔	1⅔
6	Corrosive sublimate	Rural N. Y.	442	434	8	1⅔	
7	Formalin	Rural N. Y.	563	515	48	8½	11
8	Formalin	Rural N. Y.	593	512	81	13½	
9	Non-experimental	----	----	----	----	------	
10	Insolation	Delaware	745	570	175	23½	18¼
11	Insolation	Delaware	1019	882	137	13	
12	Insolation	Rural N. Y.	441	363	78	17⅔	15¼
13	Insolation	Rural N. Y.	513	447	66	12⅔	
14	Non-experimental	----	----	----	----	------	
15	Sulphur	Delaware	512	420	92	18	19
16	Sulphur	Rural N. Y.	738	590	148	20	
17	Untreated	Delaware	568	398	170	30	31¼
18	Untreated	Delaware	615	415	200	32½	
19	Untreated	Rural N. Y.	585	360	225	38	51
20	Untreated	Rural N. Y.	488	245	243	50	
21	Untreated	Rural N. Y.	487	169	318	65	

GENERAL AVERAGES

Corrosive sublimate	3⅔	per cent of tubers scabby.
Formalin	9	" " " " "
Insolation	16¾	" " " " "
Sulphur	19	" " " " "
Untreated	41	" " " " "

Field II.—Planted May 23, in drills three feet apart; dug October 1. The soil conditions of this field have been described (page 274). As there stated, it was foreseen that the results might be complicated somewhat by scab fungus already in the soil, but it was hoped that this would not be serious enough to interfere with the interpretation of the results. Examination of the table which follows shows that the entire crop was much more scabby than in Field I, and, moreover, the scabby condition of the tubers from rows where the seed was disinfected with corrosive sublimate and formalin is conclusive evidence to us that there was a considerable amount of the scab fungus in the soil. This is unfortunate in some ways since it complicates and obscures the results. There was, however, a striking difference in the *degree* of scabbiness of the tubers from the various rows. They were sorted into three grades according to this, and in our judgment the relative amount of medium and very scabby tubers is a fairly safe index to the disinfecting action of treatment upon seed. None of the tubers were injured by any treatment used except those disinfected by the sun. These were over-exposed, scorching the shoots so that very few grew. The plan of the plots and details as to results, appear in the following table. More critical discussion of these results will be given later in this article.

FIELD II. PLAN AND RESULTS

Row number	Treatment	Variety	Total number of tubers.	Number of clean tubers	No. of slightly scabby tubers	No. of medium scabby tubers	No. of very scabby tubers	Total No. of scabby tubers	Percent of scabby tubers
1	Untreated	Rural N. Y.	333	144	94	49	46	189	59
2	Untreated	Rural N. Y.	328	129	140	41	28	209	
3	Non-experimental	---	---	---	---	---	---	---	
4	Non-experimental	---	---	---	---	---	---	---	
5	Formalin, March 28	Rural N. Y.	378	227	138	11	2	151	54
6	Formalin, March 28	Rural N. Y.	365	260	102	3	0	105	
7	Formalin, May 21	Rural N. Y.	124	112	10	2	0	12	18
8	Formalin, May 21	Rural N. Y.	383	303	73	7	0	80	
9	Corrosive sublimate, May 21	Rural N. Y.	405	326	55	24	0	79	22
10	Corrosive sublimate, May 21	Rural N. Y.	397	297	297	0	0	100	
11	Untreated	Delaware	333	328	46	23	36	105	
12	Non-experimental	---	---	---	---	---	---	---	
13	Insolation	Delaware	38	32	2	4	0	6	16
14	Insolation	Rural N. Y.	74	40	18	12	4	34	46
15	Non-experimental	---	---	---	---	---	---	---	
16	Sulphur	Rural N. Y.	215	152	30	14	19	63	29
17	Non-experimental	---	---	---	---	---	---	---	
18	Sulphur fumes	Rural N. Y.	248	156	77	15	0	92	37
19	Non-experimental	---	---	---	---	---	---	---	
20	Formaldehyde gas	Rural N. Y.	312	258	39	15	0	54	17
21	Sulphur	Delaware	251	116	105	28	2	135	54
22	Non-experimental	---	---	---	---	---	---	---	
23	Formalin, March 28	Delaware	323	154	139	27	3	169	52
24	Formalin, March 28	Delaware	323	158	131	34	0	165	
25	Formalin, May 21	Delaware	278	187	73	17	1	91	38
26	Formalin, May 21	Delaware	344	196	137	11	0	148	
27	Corrosive sublimate, March 28	Delaware	312	143	105	58	6	169	56
28	Corrosive sublimate, March 28	Delaware	255	106	115	33	0	149	
29	Corrosive sublimate, May 21	Delaware	314	129	156	29	0	185	53
30	Corrosive sublimate, May 21	Delaware	223	124	62	46	11	99	

Field III.—As previously explained (page 274) this was a clay loam where a very scabby crop of potatoes was grown last year. These plots were planned on the supposition that the scab fungus was in the soil and, unless checked by some treatment, would lead to scabbiness in the crop of this season. The results showed that the fungus was there, but as will be seen no treatment tried prevented the scabbing.

Delaware potatoes were planted, and smooth seed potatoes were used in all the rows except No. 3. There were five rows, each eight rods long, planted June 7, dug October 1. The arrangement of rows and treatment of the seed was as follows :

Rows No. 1 and 2—Smooth seed, disinfected with formalin solution.

Row No. 3—Scabby seed, rolled in sulphur and sulphur scattered in the drill.

Rows No. 4 and 5—Smooth seed, disinfected with formalin and sulphur used as in row 3.

The flowers of sulphur was used very freely in rows 3, 4 and 5, at the of about 475 pounds to the acre. It was supposed from Halsted's

results that this would reduce the scab to a considerable degree. We were disappointed, therefore upon digging to find that every potato in the five rows was scabby, most of them so badly as to be worthless for market purposes. Moreover there was no appreciable difference between the rows. The preservative action of the sulphur was apparent in that some of the pieces used for seed were firm and nearly or quite sound when dug up. The sulphur was also found well scattered through the soil. In many cases the tubers were visibly coated with the sulphur, showing that they had developed in intimate contact with it, and yet upon brushing this aside, scab spots were found in abundance. We are reluctantly forced therefore to the conclusion that in a badly infected soil like this, neither disinfection of the seed, nor the use of sulphur in the drill, nor both combined, can be depended upon to prevent the scab. It should be noted in this connection, however, that in Field I, where the soil was free from the fungus, the results from the use of sulphur were more favorable to it.

DISCUSSION OF THE RESULTS

The following conclusions seem justified by analyses of the results from the three fields:

1. Where the soil was free from the scab germs and scabby seed was used, a scabby crop resulted. (See Field I, rows 17-21.)

2. Where the soil was clean and the seed was properly disinfected, a practically clean crop resulted. (See Field I, rows 1-8.)

3. Where the soil was badly infected, no method of treatment was effective. (See Field III.)

4. If a soil becomes infested with the scab fungus, the fungus may persist in it for an indefinite period, even if it is not cropped with potatoes meanwhile. (See Field II, which had no potato crop for at least seven years previous to this.)

5. Corrosive sublimate and formalin in solution both proved to be excellent disinfectants, and either may be depended upon in practice. These are standard remedies whose value has been demonstrated by repeated trials and by numerous experiments. The corrosive sublimate apparently gave slightly better results in this season's trials. This is, however, to be offset against the fact that the reverse was true last season, when the formalin gave slightly better results.[1] We prefer to use formalin since it is more convenient and is non-poisonous to animals.

6. If formalin solution is used, it is better to disinfect the seed only a short time, one or two days, before planting, rather than two or three months before. A comparison of rows 7 and 8 with 5 and 6, in field II, also 25 and 26 with 23 and 24, shows that the ones disinfected just before planting,

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1 Vt. Exp. Sta. Rpt. 11, p. 195 (1898).

were freer from scab. This was an unexpected result and may be explained in either of two or three ways, such as retention of the fungicide on the seed pieces, incomplete sterilization and subsequent recovery of the fungus, possible recontamination of the seed, etc., but whatever the explanation, the conclusion remains the same.

7. If corrosive sublimate solution is used, the sterilization may be made two months before planting time with just as good results as at a later date. (Field II, rows 27–30). The evidence from our experiments in previous years, leads us to recommend such earlier use of this solution as it may otherwise retard germination.[1]

8. Flowers of sulphur is distinctly inferior for the disinfection of badly scabbed seed to either the corrosive sublimate or the formalin solution (Field I, rows 15 and 16, and rows 1-8). Since it is also inefficient in badly contaminated soil (Field III) there seems no good reason why it should be used.

9. Exposure to the sunlight (insolation) of tubers designed for seed, for four weeks previous to planting, greatly reduced the amount of scab and gave a pretty clean crop even when very scabby seed was used. (Field I, rows 10-12 and 17-21). Since the fungus in the deeper scab spots in such scabby seed must escape the direct action of the sun's rays, it seems fair to conclude that the effect of insolation upon seed which has no deep scab spots would be proportionately much greater. Since even with the scabby seed used in Field I, insolation gave better results than the use of sulphur (300 pounds to the acre), it is a treatment of decided value. The practical merits of this treatment are also much enhanced by the fact that such exposure to sunlight so hastens the growth of the tubers that it is often practiced for this latter reason alone.

10. Exposure of seed potatoes to sulphurous gas, has been strongly advocated by Mr. Norton of Kansas. Our own trial of this (Field II, row 18) was inconclusive, owing to the fact that the soil of this plot was apparently previously infested with the scab-fungus. So far as the evidence goes, however, it indicates that this treatment is less efficacious than soaking in either corrosive sublimate or formalin or than exposing to formaldehyde gas. In our experiments the seed potatoes were not injured by exposure of twenty-four hours in an air-tight compartment in which sulphur had been burned in quantity amounting to 1 gram for 8 cubic feet of space, which is at the rate of 1 ounce of sulphur in 250 cubic feet. We consider this method worthy of further trial, but do not consider its value fully demonstrated by any evidence which has come to our knowledge.

11. Formaldehyde gas is a very powerful disinfectant, but comparatively harmless to animals and to the higher plants. Its value in disin-

1 Vt. Exp. Sta. Rpt. 11, p. 193 (1898).

fecting hospitals, sick-rooms and similar places where a gaseous germicide is desired, has been fully established by critical experiments. It is presumable, therefore, that it will have similar value for disinfecting seeds and plants which are not injured by it. Our trial of this for disinfecting potatoes was confined to a single row (Field II, row 20) and this was unfortunately located in the field where the soil showed evidence of previous contamination. It is not, therefore, as conclusive or satisfactory as is desirable. It is significant, however, that it gave the *best results of the entire field, being superior to both the formalin and corrosive sublimate solutions.* While we do not feel justified in recommending it as a substitute for these standard remedies on the strength of this one trial, we do believe that there is reason to hope that further trial will prove that it has great practical value. Its experimental use is, therefore, strongly commended.

LEAF-SCORCHING OF TREES BY THE WIND[1]

About July first, 1900, there occurred a sudden and peculiar "blighting" of the leaves of many trees and shrubs. It was first noticed that the leaves were dying on one side of an elderberry at the Experiment station farm. Examination showed that it was not because of insect or fungus attacks. Further observation revealed similar troubles upon numerous other neighboring trees and shrubs, and here again it was only the one side, the west, that was blighting. With the elderberry and similar slender leaf blades, the blighting began at the tips and margins. The broader leaves, like maple, frequently showed dead margins also, but dead spots occurred in addition scattered irregularly between the larger veins. Numerous inquiries, with similar specimens, came from other parts of the Champlain valley, indicating that the trouble was wide spread.

We have since had opportunity to observe it in many cases, and the characters already noted have held good. In one case, a whole line of maple shade trees was seen where the west side appeared as if scorched by fire, though the east side was not harmed. The outer trees along the west margins of woodlands suffered noticeably. Maples were affected most, but similar injury was observed on many of the other deciduous trees including beech, oak, hop-hornbeam, elm, hickory, ash and fruit trees. One fruit grower reported serious injury to young plums.

The cause.—The injury was unquestionably the result of a peculiar combination of weather conditions. The last ten days of June were continuously clear, bright, hot and dry. Several days before the injury was seen, an unusually heavy, dry, west wind blew throughout one day, accompanied by hot sunshine. It was then that the injury occurred. It was due to

1 The account is based on observations and conclusions of A. W. Edson, now assistant botanist.

excessive loss of water through transpiration induced by this wind, and so differed somewhat from the more usual leaf-scorch which is primarily attributable to the hot sun. This wind could hardly have caused the trouble, however, had not the preceding dry, bright, hot days reduced the water content of the plant to a low point. Trees that were sheltered from the wind escaped, as did many of those exposed where the soil conditions were especially favorable. The occurrence of the injury almost wholly on the west side of the plants is, of course, in part, attributable to the greater exposure of that side to the westerly wind. The full explanation is probably to be found, however, in the fact that the hot, bright rays of the afternoon sun were combined with the west wind in hastening transpiration.

At this same time many young shade and fruit trees died. In some places this same wind blasted the rose-buds, by drying their outer petals so that they died, and the normal development of the flowers was prevented, although the green leaves were not injured. With the exception of trees recently transplanted, there will probably be little permanent injury.

KILLING WEEDS WITH CHEMICALS

I. SULPHURIC ACID COMPARED WITH SALT FOR THE ORANGE HAWKWEED

Investigation at this station upon the orange hawkweed[1] has shown that salt applied at the rate of one to two tons to the acre will kill it, and that this amount of salt does not seriously injure the grass, at least on clay soil. Many correspondents, following these directions, have used salt with success in destroying this weed. Occasionally, however, some one writes that this remedy has failed. In a letter recently received from New York it was stated that sulphuric acid, 1 part in 40 parts of water, had proved efficient, while salt had not. It seemed desirable, therefore, to repeat the experiments with salt and to test the sulphuric acid in comparison.

July 19, sulphuric acid, diluted as above, was applied to a plot of almost pure hawkweed. About four gallons was used to the square rod which sufficied to wet all the plants thoroughly. The effect was immediate. Every plant of weed and grass on the plot blackened and apparently died. The leaves bleached in the next few days so that the plot became very conspicuous and it certainly looked as if the sulphuric acid treatment was a success. On July 27 it was noticed, however, that the hawkweed plants were recovering. The dead leaves had mostly disappeared by this time. But from the crown of each apparently dead plant, tiny green leaves were being sent out. Evidently the plants were going to recover.

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1 Vt. Sta. Rpt. 10, p. 62, (1896).

As there had been considerable rain since this application was made, it was thought best to give the acid another trial, and also to compare its action more directly with that of salt. Accordingly six plots were measured out and applications were made July 27, in the following amounts to the square rod :

Plot 1.	1 part sulphuric acid in 80 parts water,	4 gallons	per	square	rod.
" 2.	12 pounds salt......		"	"	"
" 3.	1 part sulphuric acid in 40 parts water,	1 gallon	"	"	"
" 4.	1 " " " " 60 " "	2 "	"	"	"
" 5.	25 pounds salt......		"	"	"
" 6.	1 part sulphuric acid in 40 parts water,	2 gallons	"	"	"

The sulphuric acid had, in all cases, the same immediate effect as before, while the salt was more slow in its action. On August 3, one week later, the plots were carefully examined and compared.

In plot 1 (acid) the plants seemed entirely killed, except that a very few showed life in the crown. The grass also seemed killed.

Plot 2 (salt) there was not a green part left to any hawkweed. The grass and clover plants were not killed.

Plot 3 (acid), only about one-half the hawkweeds were killed.

Plot 4 (acid) was not quite so good as plot 1.

Plot 5 (salt), every weed was killed and some grass was left.

Plot 6 (acid) was not quite so good as 4.

On August 9, the plants in the four plots treated with sulphuric acid were sending out new leaves at the crown.

In plot 2 but one live hawkweed could be found ; grass was doing well. In plot 5 not a single hawkweed remained. From this time on the hawkweed gradually recovered in plots treated with sulphuric acid, while those treated with salt remained practically free from the weed.

September 5, when the final notes were taken the sulphuric acid plots were scarcely distinguishable from the untreated ground about them, being entirely covered with the weed. The salt plots were in striking contrast, there being but half a dozen hawkweed plants alive in plot 2, and not a single one could be found in plot 5. The grass on both of these salt plots continued to make a good growth.

These results indicate that sulphuric acid is not to be compared with salt as a remedy for the hawkweed. With more confidence than ever, we can say that salt is the best chemical yet tried for killing hawkweed and that, when properly used it is entirely effective.

In closing, we will repeat what we have frequently stated regarding the use of salt. Salt kills the hawkweed by drawing water from its tissues rather than by any poisonous or toxic action. To succeed, therefore, the salt should be applied dry (not as a brine) and upon a hot, sunshiny day,

preferably during a period of dry weather. Scatter it uniformly, broadcast, so as to come in contact with all the plants, using from 12 to 18 pounds to the square rod, which is equivalent to one ton or one and one-half tons to the acre. We also would emphasize again the fact that this weed is easily killed by cultivation where that it is practicable, and that the use of salt is recommended only for isolated patches of the weed or in soil where cultivation is impracticable.

II. KILLING KALE WITH COPPER SULPHATE

The use of copper sulphate as a spray for killing charlock and other weeds, has been advocated for several years past in Europe and Australia.[1] In this country it has been favorably reported upon by at least two experimenters.[2]

The concensus of these results is that certain weeds are readily destroyed when in the earlier stages of their development, by spraying with copper sulphate, 1 to 5 percent solutions, 40 to 50 gallons to the acre, and that cereals such as wheat, barley and oats are but slightly injured by such spraying.

The weed for which this spraying has been most generally recommended is charlock, *Brassica Sinapistrum*. This is one of the four weeds which pass in Vermont under the common name of "kale."

The other three "kales" are wild turnip, *B. campestris*, black mustard, *B. nigra*, and indian mustard, *B. juncea*. Of these the last two are not as yet common enough to rank as serious pests but the wild turnip vies with the charlock as a weed in many Vermont grain fields.

These two may be distinguished by the fact that the charlock has leaves more or less hairy and rough to the touch, whereas the leaves of the wild turnip are smooth and glaucous, that is to say, they have a bluish-white bloom upon the surface as in the cultivated turnip and rutabaga. The wild turnip also differs from the other three in that its upper leaves are sessile and auricled, that is, they are without leaf-stem and have two ear-like lobes at the base which clasp the main stem on either side, whereas, in the other three species, these upper leaves have distinct petioles or leaf-stems.

It was thought desirable to make trial of the copper sulphate spray upon these "kales" in order to verify the favorable conclusions reached by other experimenters, and also to learn whether this remedy, which has proved so effective for charlock, is equally useful in destroying the wild turnip. Accordingly on June 13 three plots—numbers 1, 2 and 3 of the

1 See Exp. Sta. Rec. 10, p. 1049 : (1899) 11, p. 461 and p. 856 (1899-1900).
2 Bolley, H. L., Proc. Soc. Prom. Ag. Sci. 20, p, 107 (1899).
Shutt, F. T., Canada Exp. Farms, Rpt. for 1899 p. 194.

table which follows, each one rod square, were staked out in a field of oats in which there were many "kale" plants. The oat plants were only three or four inches high. The "kales" included the desired two species, charlock and wild turnip. The plants were mostly from three to six inches high. About one-half had formed the basal leaves only, some were budded but none were in blossom. The applications were made about three o'clock in the afternoon of a bright warm day. During the following night there were heavy showers which, no doubt, modified the results on these plots. The solutions used were three and five percent.

Three hours after the applications were made the plants seemed to be considerably affected. Two days later, on June 15, some of the plants were dead and a large number of the others were evidently dying as the leaves were badly spotted and the edges curled and dead. On the ninth day, June 22, approximately one-fourth of the plants were entirely dead, one-half were affected and one-fourth seemed to be uninjured. July 5, one-half of the plants were entirely killed. The results are summarized in the table at the end of this article.

June 23 another application was made to plot 3 and two more similar plots, 4 and 5, were staked out and sprayed. The applications were made at nine o'clock in the morning. The day was very bright and sunny with a hot dry wind. There was no rain for several days following. The plants were somewhat larger than when the other plots were sprayed, many of them being in bud or early blossom. The larger size of the kale plants and the fact that they were somewhat shielded by the oats which were now ten inches high, both tended to lessen the destruction of the kale by the solution. But the results were more satisfactory than from the earlier spraying, owing to the favorable weather conditions.

As shown in the table below nearly 70 percent of the plants were killed and still others injured. It was observed that in many cases where the spray did not entirely destroy the kale plants it was only the lower leaves that survived. This was almost equal as a practical result to the death of the plant since such plants matured little or no seed.

Unfortunately no separate record was made of the exact numbers of charlock and of wild turnip in these plots. The general behavior of the two weeds under the treatment was, however, observed. Practically every plant of charlock was killed by the spraying of June 23 and most were killed by that of June 13. The wild turnip was more resistant. This was apparently due to the smoothness and "bloom" of the leaves since the solution rolled off the plants entirely or gathered in drops as if on an oiled surface. Most of the plants that survived the spraying were of this species, and, so far as could be estimated at the close of the experiment, not over one half of the wild turnip plants on the five plots had been killed. The oat plants were slightly injured especially by the stronger solution but soon

entirely recovered. The injury to them was not enough to be taken into practical consideration.

These results are in accord with all the previous trials reported so far as concerns the charlock and it may be stated with confidence that this kind of "kale" can be destroyed by spraying with a weak solution of copper sulphate. It is recommended that the solution contain about 1 pound of sulphate to 4 gallons of water if the charlock plants are so old as to have thrown up flower stalks—and 1 pound to 6 gallons if they are younger. The earlier applications will probably prove the more desirable. Some European experimenters even recommend that such an early application be soon followed by a second spraying. The solution should be applied with a spray pump supplied with a fine nozzle. With this it requires from 30 to 60 gallons (approximately one barrel) to the acre.

Since copper sulphate costs but 5 to 10 cents a pound the expense, other than for labor, is small and the operation may in many cases be a profitable one. Anyone contemplating the trial should, however, first examine his kale plants carefully and determine that they are the charlock rather than the wild turnip, since it is questionable if the treatment will pay upon the latter plant.

In conclusion, however, we wish to add our conviction, that the preferable way to handle kale and most other weeds in tillable land is, in general, not by the use of chemicals but by shorter rotations, more clover and corn, and cleaner cultivation.

SUMMARY OF EFFECTS OF SPRAYING UPON KALE PLANTS

Plot	I			II			III			IV			V		
Solution used	5% Copper Sulphate			3% Copper Sulphate			3% Copper Sulphate			3% Copper Sulphate			3% Copper Sulphate		
Date when sprayed	June 13			June 13			June 13 June 23			June 23			June 23		
No. of kale plants when sprayed	136			130			115			92			86		
Condition of kale plants on following dates	Uninjured	Affected	Dead	Uninjured	Affected	Dead	Uninjured	Affected	Dead	Uninjured	Affected	Dead	Uninjured	Affected	Dead
June 15	3														
June 23	31	73	32	18	66	46	17	87	1						
July 5	31	53	52	18	60	52	17	15	83	11	21	58	19	9	58

IMPURITIES OF GRASS AND CLOVER SEEDS

The botanical department is called upon with increasing frequency, to give advice regarding recently introduced plants which threaten to become weeds. Grass and clover seeds constitute the principal channel of introduction of such plants. The more careful farmers appreciate this and often ask the station for advice relating to seed purchases. The matter of weed legislation and official inspection of agricultural seeds has come up for discussion before recent legislative committees, and they also have asked the station for advice. Seed inspection is not the highest type of experiment station work, but it has seemed wise, in view of these facts, to give at least so much time to it as is necessary properly to answer such questions. This requires a knowledge of the kind and amount of impurities occurring in the average seeds offered for sale in the state. A beginning was made in the acquisition of such knowledge in 1897, when examinations were made of samples of clover and grass seeds contributed by twenty-five farmers from various localities in the state. The results of this inspection may be found in the eleventh annual report of the Vermont experiment station, page 229. Wishing to extend this investigation, the station last spring sent a request for samples of seed to over one hundred farmers throughout the state. In each case the request was made that these samples be so collected as to fairly represent the seeds furnished to the farmers of the community. The responses were very generous, resulting in over two hundred samples of alsike and red clover, of timothy and other grass seeds. The seeds of timothy and of red clover so obtained have been carefully examined as to purity.[1] Examinations of the others are under way but are not as yet completed. In accordance with the regulations governing seed tests made by the Department of agriculture, five-gram samples of clover were taken and two-gram samples of timothy. The impurities were divided into two classes: (1) *Inert matter*, including chaff, straws, dirt, broken seeds, &c.; (2) *Viable seeds*, including all foreign seeds which were apparently sound. These two classes of impurities were then weighed separately, and the results of such weights are expressed in percents in the tables. The viable seeds were further sorted, the species of each kind determined and the number counted. These foreign seeds are for practical purposes readily divisible into two classes: useful seeds, including the valuable grasses and clovers; and noxious seeds, including the weedy plants. The importance of this division is evidently great, and in tabulating the results we have so differentiated them. The results of the examinations are shown in the following tables:

1 To obtain full data for determining the value of seed it is also necessary to make germination tests. It was not possible to do this in the case of these samples, nor has the station as yet considered it expedient to offer to do this for farmers. Satisfactory germination tests can be made by anyone by simply placing seeds between two pieces of moist flannel, at the temperature of the ordinary living room. The flannel may by inclosed between two plates to prevent drying.

TABLE I. IMPURITIES IN RED CLOVER

Sample number	Sent by	Where bought	Price in cents per pound	Percent total impurities	Percent inert matter	Percent foreign seeds	Detailed statement of kind and number of foreign seeds in 5 grams: Noxious foreign seeds																													Useful foreign seeds					Grass Sp. undetermined	Seeds undetermined
							Chickweed	Red-root	Roman Wormwood	May weed	Charlock	Self-Heal	Yellow Foxtail	Green Foxtail	German Millet	Pigweed	Canada Thistle	White Daisy	Spurge	Spotted Spurge	Pepper-grass	Hair-grass	Barn-yard grass	Small Crab-grass	Crab-grass	Paspalum	Bracted Plantain	English Plantain	Common Plantain	Red-stem Plantain	Smart-weed	Sheep Sorrel	Curled Dock	Penny Cress	Vervain	Alfalfa	Millet	Timothy	White Clover	Alsike Clover		
1	O. T. Ware	Brattleboro	12	0	0	0	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	W. O. Hinds	Bridport	10½	14.	1.4	13.6	--	--	--	--	15	--	--	112	--	84	--	--	--	--	--	--	--	--	--	--	7	4	--	38	13	9	22	--	--	--	--	540	--	--	2	8
3	" "	"	9½	3.5	.7	2.8	--	2	--	--	5	--	--	21	--	--	--	--	--	--	--	--	--	--	--	--	1	7	--	21	--	--	4	--	--	--	--	22	--	--	--	--
4	B. W. Crane	Troy, N. Y.	8½	2.5	.7	1.8	--	--	--	--	--	--	--	9	--	5	--	--	--	--	--	3	--	--	--	--	1	4	--	22	2	--	5	--	1	--	--	7	--	--	1	1
5	" "	" "	9	2.	.5	1.5	--	3	--	--	--	--	--	19	--	--	--	--	--	--	--	--	--	--	--	--	1	2	--	17	--	2	3	--	--	--	--	11	--	--	--	--
6	J. B. Peckham	Montpelier	10	1.6	.5	1.1	--	--	--	--	--	--	--	20	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	11	2	3	2	--	--	--	--	2	--	--	--	1
7	L. C. Fisher	Portland, Me.	8½	3.3	.4	2.9	--	--	--	--	1	--	--	50	--	8	--	--	--	--	--	--	--	--	1	--	2	7	--	5	7	1	1	--	--	--	--	18	--	--	--	--
8	" "	" "	12	6.6	1.1	5.5	--	--	--	--	7	--	--	104	--	7	--	--	--	--	--	--	--	--	2	16	1	--	--	2	10	3	11	--	--	--	--	56	--	--	--	--
9	L. Putnam	Cambridge	11	4.2	.6	3.6	--	1	--	--	--	--	--	42	--	21	--	--	--	--	--	--	--	6	1	7	2	5	--	18	2	9	2	--	--	--	--	73	--	--	--	--
10	John Mitchell	Fairfield	9 1-6	6.	1.2	5 8	--	--	--	--	11	--	--	102	--	26	--	--	--	--	--	--	--	--	--	6	2	1	--	3	--	4	7	--	--	2	--	55	--	2	--	--
11	G. T. Alpin	Brattleboro	9	6.	1.	5.	--	9	--	--	--	--	6	48	--	28	--	--	--	--	--	4	--	--	--	--	--	--	--	16	11	2	2	--	1	--	--	65	--	--	6	4
12	" "	"	10	.6	.1	.5	--	2	--	--	6	--	--	4	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	9	2	--	1	--	--	--	--	---	--	--	--	--
13	Dix J. Camp	E. Randolph	10½	2.5	.5	2.	--	--	--	--	--	--	--	19	--	--	--	--	--	--	--	2	2	--	--	--	--	1	--	16	--	8	2	--	--	--	--	31	--	--	2	[illegible]
14	Clarence Bedell	E. Ryegate	10	7.5	1.1	6.5	--	--	--	--	10	--	--	85	--	44	--	--	--	--	--	--	--	--	--	9	3	--	--	3	15	8	6	--	--	--	--	85	--	--	--	--
15	M. P. Perley & Co.	Enosburgh Falls	10	0	0	0	--	--	--	--	--	--	--	---	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	---	--	--	--	--	--	--	--	---	--	--	--	--
16	J. B. Maxfield	Cambridge	10	2.9	1.	1.9	--	5	--	--	--	--	--	15	--	9	--	--	--	--	--	--	--	--	--	--	2	3	--	15	3	--	3	--	--	--	--	24	--	--	2	--
17	L. H. Sheldon	Fairhaven	-----	0.5	0	0.5	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	---	5	--	--	--	--	--	--	---	--	--	--	--
18	" "	"	10	0.5	---	0.5	--	--	--	--	--	--	--	---	--	--	--	--	--	--	--	--	--	--	1	2	--	--	--	---	4	--	2	--	--	--	--	---	--	--	--	--
19	W. F. Clark	Glover	10	1.7	.4	1.3	--	--	--	--	--	--	3	---	--	--	--	1	--	--	--	4	--	--	6	--	4	7	--	16	--	--	1	--	--	--	--	---	--	--	--	--
20	L. J. Sanderson	Highgate	10	8.2	2.	6.2	--	4	--	--	1	--	1	39	--	16	--	--	--	--	--	--	1	1	1	5	2	3	--	25	4	6	9	--	--	--	--	90	--	--	--	--
21	L. W. Barton	Ludlow	10	3.5	.6	2.9	--	3	--	--	4	--	--	33	--	6	--	--	--	--	--	--	--	--	1	5	4	2	--	7	11	--	--	--	--	--	--	15	--	--	--	--
22	L. B. Harris	Lyndonville	10	5.2	.8	4.4	--	20	--	2	--	--	2	4	--	--	--	--	4	--	--	3	--	1	--	2	3	20	--	36	12	7	14	--	--	--	--	94	--	--	--	4
23	U. M. Canfield	Manchester	9½	.1	.1	---	--	--	--	--	--	--	2	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	---	--	--	--	--	--	--	--	---	--	--	--	--
24	" "	"	10	.3	.3	---	--	--	--	--	--	--	--	---	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	---	--	--	--	--	--	--	--	---	--	--	--	--
25	C. F. Smith	Chicago	10	2.2	.4	1.8	--	--	--	--	--	--	--	10	--	10	--	--	--	--	--	2	--	1	1	--	5	6	--	15	2	4	2	--	--	--	--	48	--	--	--	--
26	" "	Morrisville	10	7.4	1.	6.4	--	1	--	--	6	--	2	75	--	50	--	--	--	--	--	--	--	--	1	4	1	6	--	5	6	5	5	1	--	--	--	114	--	--	--	--
27	M. O. Howe	Newfane	10	5.	.6	4.4	--	3	--	--	--	--	--	29	--	33	--	--	--	--	--	2	--	--	2	--	5	7	--	44	--	5	1	--	--	--	--	51	--	--	1	2
28	J. C. Wilder	New Haven	11	3.6	.8	2.8	--	3	--	--	--	--	--	23	--	7	--	--	--	--	--	2	--	--	2	--	1	2	--	19	1	10	4	--	--	--	--	62	--	--	--	--

29	J. C. Wilder	Vergennes	10½	2.7	.4	2.3																					3	5		17								196				1
30	L. M. Macomber	N. Ferrisburgh	12	.6	.3	.3										1								2														13				
31	F. L. Davis	Woodstock	7½	6.2	1.4	4.8		7			1		2	35		1	1					5	1	4	2	4	1			18	14	6				6	1	105				
32	" "	"	10½	.9	.4	.5																		1				9	3	18												
33	J. R. Kenerson	Peacham	10	8.	.6	7.4		10		4			1	28		24						3	1	10	5	4	2	3		66		17				7		230				
†34	" "	"	9	11.6	11.1	.5								1														1		6	2					2		6			1	
35	Edwd. Gordon	Plattsburgh, N. Y.	10	7.2	1.	6.2				1				32		29						2	1	1			1			50	6	17				4		241			1	
36	" "	Burlington	-----	.5	0	.5								2																	1		13					1				
37	" "	Plattsburgh, N. Y.	9	4.	.4	3.6			1					12								1						13		3	4		3					105				
38	C. K. & A. B. Hawkins		-----	0	0	0										1																						1				
39	E. Hitchcock	Rutland	10	5.3	.6	4.7		4						24		1				1		4		1	2	1	1	2		29		6	42			3		50	2			
40	F. W. Spaulding	Poultney	10	3	.5	2.5		1						39								1			1	1		1		14	1	1	16			1		19	6			
41	J. B. Gorham	Putney	10	7.7	.8	6 9		4					2	57		20						2	1			8		2		48	7	34	27			6		83	7	6		4
42	" "	"	-----	3.4	.8	2.6			1					14		1						1	1	3		5		3		6	1	4	9			1		39	7			
43	D. H. Morse	Randolph	9	4.7	1.	3.7		7			1			27		10						5		8						43	3	7	9			2		117	7			2
44	" "	"	10	2.9	.5	2.4			1					6		2								1		2				9			15					9	24			
45	" "	"	10	2.4	.6	1.8		1					1	15											1	3				3	4	2	20					7	3			
46	" "	"	10	2.1	.6	1.5							2	9		1								1		3		1		8	1	1	10					8	2	7		3
47	Alpha Messer	Rochester	15	.5	.0	.5								5																3	2		2					2	4			3
48	" "	"	11	1.8	.2	1.6								15															2		4		9			1			2			
49	" "	"	10	8.	1.7	6.3				4			8	17		1					1	3								182		1				6						
50	D. K. Hall	Rutland	9½	1.7	.0	1.7																					1	12		7		1	6			1		95				2
51	" "	"	11	.5	.0	.5		1						5	1																		15						1			
52	" "	"	8½	1.6	.3	1.3									4												4	12		5		1	9					6			1	4
53	" "	"	9	.5	.1	.4																	1															1	8			
54	E. S. Brigham	St. Albans	11	2.7	.1	2.6				2				12										1			2	31		14	3	1						20				
55	" "	" "	12	5.6	.4	5.2	1	4		3				10		20			1		2	9				1				5		41	10	1			1	170	29			
56	H. C. Bruce	Sharon	10	.7	.4	.3								14																	1	1	2		1				1			
57	" "	"	10	5.4	.9	4.5		8		5				9		1			4			4		6		7	7	2		31	7	32	9			10		57	7		1	5
58	R. H. Holmes	Shoreham	10	1.2	.4	.8								6												2	7			12			5					4	4			
59	" "	"	10	.5	.2	.3								4									1			4					2					2						2
60	F. B. Pier	Brattleboro	7½	2.6	.9	1.7		2			2			18		2						2		2		4				5	5	3	5					33	4			
61	L. M. Cragin	Springfield	11	10.9	1.4	8.6	1				15			80		42										6	2	3		2	20	8				8		110	5			3
62	" "	"	10	.6	---	---																				2		2		2	5	1						3				
63	" "	"	10	2.9	.6	2.3	1	5		2				20		7						1		1		1		1		8	8	8	1			6		72	17	8		6
64	J. S. Woodard	Brattleboro	12	.7	.2	.5								2		2												2		5		1						12			3	2
65	E. O. Lee	Buffalo, N. Y.	10	.3	.1	.2								6																		1						3				
66	F. S. Hale	Windsor	10	5.5	.7	4.8		15						28		6						1	1	16	1	6				25	5		33					99	3			
67	Geo. Aitken	Woodstock	11	4.4	.2	2.2	1	1		1			2	32		22			1			2	1	6		2		11		22		12	20			4		120				9
68	" "	"	11	1.6	.3	1.3		1						5		5								1				1			2		4			7		8	15		1	
69	L. W. English	"	10	5.9	.1	4.9		10						24		22						3		5		2		1	6	11	4	5				2		197				
70	H. M. Pearl	Plattsburgh, N. Y.	10	.4	.3	.1																					4	5								1						
71	" "	Ravena, Ohio	7½	1.2	.1	1.1		1				1		10					2	1		1			3	1				18	1		10	1				6			2	1
72	D. K. Hall	Rutland	8½	2.2	.4	1.8								20											2	4		3		14		5	13					11				
73	C. K. & A. B. Hawkins	Troy, N. Y.	-----	2.4	.7	1.7								9								1	1	3	2	7		1		15	1	4	6			5		1				
74	" " "	" "		1.3	---	1.3								12		1												3		2	3							2	3			

† 10.7 per cent of this impurity was inert alfalfa seed.

TABLE II. IMPURITIES IN TIMOTHY SEED

Sample number	Sent by	Where bought	Price per bushel in dollars	Percent of total impurities	Percent of inert matter	Percent of foreign seeds	Number noxious foreign seeds in two grams	Number useful foreign seeds in two grams	Number of kinds of weed seeds in two grams	Detailed statement of kind and number of foreign seeds in 2 grams: Noxious foreign seeds																Useful foreign seeds			
										Red-root	May-weed	Green foxtail	Pigweed	Charlock	Pepper-grass	Evening primrose	Hair-grass	Common plantain	Red-stem plantain	Purslane	Five finger	Sheep sorrel	Curled dock	Yellow daisy	Vervain	Red Top	Alsike clover	White clover	Red clover
1	C. M. Winslow	Brandon	1.75	.5	.5	.0	1	1	1										1								1		
2	" "	"	1.75	.5	.5	.0	0	2	0																				
3	" "	"	1.80	.2	.2	.0	0	0	0																				
4	Geo. Pierce	Brattleboro	1.90	.4	.2	.2	1	2	1														1				2		
5	" "	"	1.50	.6	.3	.3	2	6	2				2															6	
6	W. O. Hinds	Vergennes	1.65	.5	.5	.0	0	1	0				3				1					1				1	1	1	
7	" "	Bridport	1.40	1.	.4	.6	5	3	3																		1		
8	B. C. Crane	Bridport	1.45	1.	.5	.5	9	3	2				2				7											3	
9	J. B. Peckham	Montpelier	1.55	.75	.5	.25	2	4	1													1	1				2	2	
10	L. C. Fisher	Portland, Me.	1.60	.75	.5	.25	9	1	3							7	1							1				1	
11	L. Putnam	Cambridge	2.00	.4	.4	.0	0	0	0																				
12	John Mitchell	Fairfield	2.00	.25	.0	.0	0	1	0																			1	
13	" "	"	1.50	1.	.5	.5	17	7	5															8				3	
14	" "	Burlington	1.65	.6	.4	.2	8	3	1				6		3	2				5				1			5	2	
15	G. T. Alpine	Brattleboro	1.60	.5	.3	.2	8	4	4				1			1			2					4			2	2	
16	" "	"	1.75	.2	.1	.1	2	3	1													2						3	
17	Dix J. Camp	E. Randolph	1.40	.4	.2	.2	2	7	2						1										1		4	3	
18	" "	"	2.00	.25	.25	.0	0	0	0																				
19	Clarence Bedell	E. Ryegate	1.45	.5	.25	.25	11	3	3				6		3										2		3		
20	L. W. English	Woodstock	1.50	7.	4.5	2.5	235	13	7				1		20				15		190	1		8				13	
21	Geo. Aitken	"	1.50	1.	.5	.5	20	11	6				5		2						1	5		6	1			11	
22	F. S. Hale	Windsor	1.50	1.5	.5	1.	43	10	5							5			5		27			5	1		3	7	
23	E. O. Lee	Vernon	1.45	2.	1.5	.5	45	4	7				9		2		1		2		8			2	1			4	
24	E. M. Bissell	Shoreham	1.50	1.5	1.	.5	41	7	4				1			9			1		30							7	
25	M. P. Perley & Co.	Enosburgh Falls	1.90	.4	.4	.0	0	0	0																				

26	" " "	" "	2.00	.3	.3	.0	0	1	0																			1	
27	" " "	" "	2.40	.4	.2	.2	3	3	1				3															3	
28	" " "	" "	1 50	1.	.7	.3	7	2	5										1	1	2	1		2			2		
29	J. B. Maxfield	Cambridge	1.75	2.5	2.	.5	55	1	5				9		3				6		32			5				1	
30	" "	"	2.00	.5	.3	.2	5	4	3						2				2					1				4	
31	L. H. Sheldon	Fairhaven	1.45	.5	.3	.2	16	1	5				3		2				4		6			1				1	
32	L. H. Sheldon	Fairhaven	1.75	.2	.2	.0	2	0	1															2					
33	W. F. Clark	Glover	1.50	1.5	1.	.5	19	14	9			3	1		1	4			2	1	2			4	1		3	11	
34	L. J. Sanderson	----	1.60	6.5	5.	1.5	123	0	8				14		8	13			7		68	1		9	3				
35	" "		1.75	.6	.35	.25	15	2	6				5		1	1			1		6			1				2	
36	" "		1.60	1.	.5	.5	27	6	3						1				2		6	3		13	2			3	
37	L. W. Barton	Ludlow	1.50	1.	.5	.5	21	6	4							1					11			7	2			6	
38	" "	"	2.00	.3	.3	.0	1	2	1								1											2	
39	" "	"	1 50	.2	.0	.2	2	2	1						2												2		
40	L. B. Harris	Lyndonville	1.50	2.	.75	1.25	25	20	4									2			13	5		5			1	18	1
41	U. M. Canfield	Manchester	1.50	.7	.7	.0	3	0	3						1						1			1					
42	C. F. Smith	Morrisville	1.60	.9	.7	.2	7	1	1	1			1					4						1			1		
43	" "	"	2.00	.1	.1	.0	0	0	0																				
44	M. O. Howe	Newfane	1.50	1.	.8	.2	6	0	3				2					2						2					
45	J. C. Wilder	New Haven	---	1.25	1.2	.05	7	0	4				1		4						1			1					
46	" "	Vergennes	1.80	.4	.4	.0	1	0	1										1										
47	D. C. Hicks	No. Clarendon	1.75	.2	.2	.0	1	0	1				1																
48	L. M. Macomber	No. Ferrisburgh	1.50	.4	.3	.1	5	0	3				1		2									2					
49	" "	" "	1.70	.1	.1	.0	0	0	0																				
50	F. L. Davis	Woodstock	1.30	5.5	4.	1.5	230	7	10		5	5	5		13	2	1	10			171	2		14	3			7	
51	J. R. Kennerson	Peacham	1.60	1.	.7	.3	30	0	4				5		13						11	1							
52	Edward Gordon	Burlington	---	.7	.2	.5	4	7	3			1	2						1									4	3
53	E. Hitchcock	Rutland	1.75	2.	1.7	.3	43	6	7		1		1		2				1	1	25			12			1		5
54	" "	"	2.00	.5	.4	.1	2	5	2												1	1					3		2
55	F. W. Spaulding	Poultney	2.25	.3	.3	.0	1	1	1																1				1
56	J. B. Gorham	Putney	1.58	4.5	2.75	1.25	210	0	4				2						8		170			26	4				
57	" "	"	1.50	.3	.29	.01	8	1	3				1		6										1		1		
58	" "	"	---	1.25	.5	.75	17	6	4				2								11			3	1		4	2	
59	D. H. Morse	Randolph	1.65	.25	.25	.0	3	0	1		2										1								
60	" "	"	1.65	.45	.4	.05	8	0	3										1		6			1					
61	" "	"	1.75	.3	.3	.0	0	0	0																				
62	M. W. Clark	Burlington	1.35	1.	.7	.3	8	3	3				4		2	2												3	
63	Alpha Messer	Rochester	2.00	9.	.4	.1	307	21	9			15	6	8	1	10					241	2		14	10		8	13	
64	" "	"	2.25	.2	.2	.0	0	4	0																			4	
65	" "	"	2.25	.1	.09	.0	0	2	0																			2	
66	" "	"	2.50	.1	.09	.2	2	2	0																			2	
67	D. K. Hall	Rutland	1.75	.3	.2	.1	6	0	1							6													
68	" "	"	1.60	.2	.2	.0	2	0	1			2																	
69	" "	"	1.70	.4	.3	.1	8	1	5				3			1			1		2	1					1		
70	" "	"	1.45	.6	.4	.2	8	4	3							1					2			5			4		
71	" "	"	1.40	1.	.7	.3	20	5	7	1			1		6				4		5			2	1			5	
72	" "	"	1.35	1.5	1.2	.3	20	3	6	1			1		1	5			2		10							3	
73	E. S. Brigham	St. Albans	1.50	.4	.3	.1	11	2	5				5		2				2		1			1				2	

TABLE II. IMPURITIES IN TIMOTHY SEED—*Continued*

Sample number	Sent by	Where bought	Price per bushel in dollars	Percent of total impurities	Per cent of inert matter	Percent of foreign seeds	Number noxious foreign seeds in two grams.	Number useful foreign seeds in two grams.	Number of kinds of weed seeds in two grams	Detailed statement of kind and number of of foreign seeds in 2 grams — Noxious foreign seeds.															Useful foreign seeds			
										Red-root	May-weed	Green foxtail	Pigweed	Charlock	Pepper-grass	Evening primrose	Hair-grass	Common plaintain	Red-stem plantain	Purslane	Five finger	Sheep sorrel	Curled dock	Yellow daisy	Vervain	Red top	Alsike clover	White clover	Red clover
74	" "	"	1.85	.2	.2	1.0	1	0	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
75	H. C. Bruce	Sharon	1.65	2.	.8	1.2	29	33	8	3	--	--	1	1	2	--	--	--	2	--	10	4	--	6	--	--	--	33	--
76	" "	"	1.65	1.8	.7	.1	50	5	4	--	--	--	--	--	--	--	--	--	11	--	21	--	--	15	3	--	--	5	--
77	C. B. Kendall	Troy, N. Y.	1.40	2.4	1.8	2.6	51	1	5	--	--	--	--	--	2	--	--	--	2	--	35	--	--	11	1	--	--	--	1
78	Waite & Stokes	Rutland	1.50	3.4	1.	.4	40	0	5	--	--	--	6	--	--	--	--	--	5	--	22	--	--	4	3	--	--	--	--
79	" "	Burlington	1.65	.9	.89	.01	4	1	1	--	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	--	1
80	F. B. Pier	Brattleboro	1.35	.4	.3	.1	8	5	3	1	--	--	--	--	6	--	--	--	1	--	--	--	--	--	--	--	4	1	--
81	L. M. Cragin	Springfield	1.60	1.5	1.2	.3	31	1	5	--	--	--	6	--	3	4	--	--	4	--	14	--	--	--	--	--	--	1	--
82	J. O. Sanford	Stamford	1.80	1.2	.8	.4	23	1	5	--	--	--	4	--	13	2	--	--	1	--	2	--	--	--	--	--	1	--	--
83	" "	"	1.50	.9	.4	.5	24	4	4	--	--	--	7	--	--	4	--	--	--	--	9	3	--	1	--	--	4	--	--
84	E. O. Lee	Buffalo, N. Y.	2.20	.2	.2	.0	1	1	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	1	--
85	" "	Brattleboro	1.90	3 5	.1	3.4	1	47	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	47	--	--

TABLE III. FOREIGN SEEDS FOUND IN TIMOTHY, SUMMARZIED BY KINDS

Latin Name	English Name	Percent of samples in which it occurred	Maximum number found in 5 grams	Equalling the following number in 1 lb.	Average number in 5 grams	Equalling the following number in 1 lb.
Noxious foreign seeds						
Amarantus sp	Red root	5	3	270	1	90
Anthemis Cotula	May weed	3	5	450	2	180
Chætochloa viridis	Green foxtail	5	15	1,350	5	450
Chenopodium album	Pigweed	42	14	1,260	3	270
Brassica Sinapistrum	Charlock	2	8	720	4	360
Lepidium Virginicum	Pepper-grass	37	20	1,800	4	360
Oenothera biennis	Evening primrose	21	13	1,170	4	360
Panicum capillare	Hair grass	7	7	630	8	720
Plantago major	Common plantain	4	10	900	4	360
Plantago Rugellii	Red-stem plantain	38	15	1,350	3	270
Portulaca oleracea	Purslane	4	5	450	2	180
Potentilla sp*	Five finger	42	241	21,690	31	2,790
Rumex acetosella	Sheep sorrel	20	20	1,800	3	270
Rumex crispus	Curled dock	2	1	90	1	90
Rudbeckia hirta	Yellow daisy	43	26	2,340	5	450
Verbena hastata	Vervain	21	10	900	2	180
Useful foreign seeds						
Agrostis alba	Red top	1	1	90	1	90
Trifolium hybridum	Alsike clover	30	47	4,230	4	360
Trifolium repens	White clover	50	33	3,070	5	450
Trifolium pratense	Red clover	8	5	450	2	180

* Apparently most if not all of this was Potentilla Monspeliensis.

ERRATA. In heading of columns 4 and 6, for 5 grams read 2 grams. In columns 5 and 7, multiply numbers by $2\frac{1}{2}$.

TABLE IV. FOREIGN SEEDS FOUND WITH RED CLOVER SUMMARIZED BY KINDS

Latin Name	English Name	Percent of sampling in which it occurred	Maximum number found in 5 grams	Equalling the following number in 1 lb.	Average number in 5 grams	Equalling the following number in 1 lb.
Noxious foreign seeds						
Alsine media	Chickweed	5	1	90	1	90
Amarantus sp	Red root	40	20	1,800	3	270
Ambrosia artimisiaefolia	Roman wormwood	4	1	90	1	90
Anthemis cotula	Mayweed	12	5	450	2	180
Brassica Sinapistrum	Charlock	17	15	1,350	6	540
Brunella vulgaris	Self-heal	1	1	90	1	90
Chætochloa glauca	Yellow foxtail	19	8	720	2	180
Chætochloa viridis	Green foxtail	81	112	10,080	20	1,800
Chenopdium album	Pigweed	51	84	7,560	14	1,260
Cnicus arvense	Canada thistle	1	1	90	1	90
Chrysan. leucanthemum	White daisy	1	1	90	1	90
Euphorbia maculata	Spotted spurge	1	1	90	1	90
Euphorbia Preslii	Spurge	6	4	360	2	180
Lepidium Virginicum	Pepper-grass	1	1	90	1	90
Panicum capillare	Hair-grass	37	9	810	3	270
Panicum Crusgalli	Barnyard-grass	17	1	90	1	90
Panicum glabrum	Small crab-grass	31	10	900	2	180
Panicum sanguinale	Crab-grass	28	6	540	1	90
Paspalum sp		48	16	1,440	4	360
Plantago aristata	Bracted plantain	43	7	630	2	180
Plantago lanceolata	English plantain	59	31	2,790	4	360
Plantago major	Common plantain	5	6	540	3	270
Plantago Rugellii	Red-stem plantain	77	182	16,380	20	1,800
Polygonum Persicaria	Smartweed	60	20	1,800	7	630
Rumex acetosella	Sheep sorrel	58	41	3,690	7	630
Rumex crispus	Curled dock	57	22	1,980	4	360
Sisymbrium officinale	Hedge mustard	1	1	90	1	90
Thlaspi arvense	Penny cress	4	1	90	1	90
Verbena hastata	Vervain	5	1	90	1	90
Useful foreign seeds						
Chætochloa Italica	German millet	1		90	1	90
Medicago sativa	Alfalfa	37	42	3,780	8	720
Panicum miliaceum	Millet	1	1	90	1	90
Phleum pratense	Timothy	79	540	48,600	63	5,670
Trifolium hybridum	Alsike clover	31	29	261	4	360
Trifolium repens	White clover	31	8	72	7	630
Grass, not determined		17	6	54	2	180
Seeds, not determined		28	8	72	3	270

TABLE V. A COMPARISON OF THE CONDITIONS OF RED CLOVER AND TIMOTHY SEED

		Total percent of impurities	Percent of inert matter	Percent of viable seed	Number of weed seeds in 1 lb.	Number of useful seeds in 1 lb.	Approximate number of seeds in 1 lb.
Red Clover	Maximum	14.	11.1	13.6	21,240	48,600	
	Minimum	0.0	0.0	0.0	0.0	0.0	
	Average	3.4	.65	2.7	5,940	7,920	336,000
Timothy	Maximum	9	5	3.5	69,382	10.622	
	Minimum	0.1	0.0	0.0	0.0	0.0	
	Average	1.1	0.7	0.3	9,040	8,475	1,175,200

DISCUSSION OF THE RESULTS

1. *Timothy seed.*—The standard of purity of timothy seed which is recommended by the United States department of agriculture is 98 per cent. This standard has no legal status, but is simply an expression of expert opinion as to what should be the purity of good commercial seed. A comparison of the results of our examinations with this standard shows that in general the timothy samples were of excellent purity. Only nine samples out of the eighty-five fell below this standard, that is, contained more than 2 per cent of impurities. These were numbers 20, 29, 34, 50, 56, 63, 77, 78, 85. Each of four other samples, numbers 23, 40, 53 and 75, were just up to the purity standard ; in other words 5 per cent were just at standard, and only 10 per cent were below standard. It is evident, therefore, that the bulk of the timothy seed sold in Vermont, assuming that our samples are fairly representative, is comparatively clean. It would appear then that there is plenty of fairly clean timothy seed on the market. The next question is, can the buyer depend upon getting clean seed if he wishes it? The evidence so far as presented in our returns lead to the conclusion that he can, and that it is largely a matter of price ; that is to say, if the buyer is willing to pay a higher price he can get clean seed, and that the foul seed is sold at a low price. Thus the average price of the 85 percent of the samples which were above the standard in purity was $1.70 a bushel, whereas the average price of the other 15 percent, those samples which were at or below standard, was $1.60. In numerous cases the same man sent two or

more samples of different price. An examination of the table shows that this occurred in the case of five out of the nine samples which were below standard. A comparison of these five with the five higher price samples sent by the same men is instructive. In each case the two samples upon the same line in the following table came from the same man.

COMPARISON OF TIMOTHY SEEDS OF DIFFERENT PRICE FROM THE SAME SOURCE

Cheaper seed				Higher price seed			
Sample No.	Price	Purity	No. weed seeds	Sample No.	Price	Purity	No. weed seeds
29	$1.75	97.5%	55	30	$2.00	99.5%	5
34	1.60	93.5%	123	35	1.75	99.4%	15
63	2.00	91.0%	307	64	2.25	99.8%	0
78	1.50	96.6%	40	79	1.65	99.1%	4
85	1.90	96.5%	1	84	2.20	99.8%	1
Averages,	$1.75	95.0%	105		$1.97	99.5%	5

The moral seems evident. The cheaper seed contained ten times the amount of total impurity and over twenty times as many weed seeds as did the higher price seed. Moreover, the higher price seed had larger and brighter kernels, and it would without doubt germinate considerably better and produce stronger plants. In consideration of all these facts it becomes evident that the same amount of money invested in the higher price seed would bring more value in seeds than would a like investment in cheap goods, and that in addition practically no weed seeds would be introduced with the high-price goods.

Comparative examination of the price and purity of these seeds shows, however, that it is the relative and not the actual price which must be taken as a criterion. Thus, sample 63 which was ths foulest seed examined cost a high price, $2.00 a bushel, but a comparison with 64 and 65, the other samples from the same place, shows that it was the cheapest seed from that source. It would seem, therefore, that if one is dealing with a good and reliable seedsman, and is willing to pay for the cleanest seed obtainable he may expect to get seeds of a good degree of purity. Comparisons often show, however, that purity and price are not properly related (compare 82 and 83, 56 and 57, 34 and 36). Such examples indicate that critical examination of the seed is after all the only certain course. The experiment station will make such examination on request.

The preceding discussion has been based on the total impurity found in the samples. The nature of the weed seeds which occur is also a matter of importance. Yellow daisy, pigweed, plantains, pepper-grass, five-finger and evening primrose are found most commonly. Sample 63 contained the astounding number of 54,225 seeds of five-finger (*Potentilla monspeliensis*?) to the pound. About 40% of the samples contained seeds of

plantain, and the yellow daisy was found in 43% of them. Most Vermont farmers will agree that they have already enough of these weeds without such extensive additional seedings.

2. *Red clover seed.*—The standard of purity recommended by the Department of agriculture for red clover seed is 98 percent. Only 29 of the 74 samples examined were up to this standard, 45 fell below it; in other words, 61 per cent were below the purity standard, and only 39 per cent above it.

Two of the clover samples (Nos. 2 and 48) contain weed seeds at the rate respectively of 19,500 and 21,200 to the pound, while eighteen of those samples showing greatest impurities average to contain 13,000 weed seeds to the pound. Of the seeds represented above, green foxtail, pigweed, red-stem plantain (*P. Rugellii*), smartweed, English plantain, sheep sorrel and curled dock are of the most common occurrence. Of these the plantain and sheep sorrel are the most injurious to the farmer. A pound of sample No. 49 would contain over 16,000 seeds of red-stem plantain, while the same amount of No. 54 would yield nearly 3,000 seeds of the English plantain, a pernicious weed which is fast gaining a foothold on many of the Vermont farms. It should be noted that several samples contain seeds of the penny-cress, a plant of the mustard family, which is the curse of the grain fields of the northwest, but is as yet almost unknown in Vermont.

As stated above, 61 percent of the samples examined fell below the purity standard recommended by the department of agriculture, and only 39 per cent exceeded this standard. The average amount of impurity of the former class was a little over five percent and that of the latter was a little less than 0.8 percent. The average price quoted on the samples of fouler seeds was 9.8 cents a pound, while that on those which were up to the purity standard was 10.2 cents.

Analysis of these figures shows at once that an average increase of four percent in price brought five percent more clover seed. In other words the purchasers of the higher grade seeds secured on the average more clover seed for the same money, and in addition avoided the weed seeds which occurred in the cheaper and fouler seeds.

The question arises at once, was price alone a safe guide to purity? The low price seeds were in general the dirtier, but it does not necessarily follow that all of the higher price seeds are of a correspondingly higher grade of purity.[1] In nineteen cases, two samples were sent by the same per-

1 A pertinent illustration of the fact that relative price is not a guarantee of relative purity has just come to hand. It is a sample of red clover seed sent by Mr. Jas. F. Dow of Waterbury Center, with the statement that it cost 12 cents a pound, and that it was bought for the highest grade seed. An examination gives the following results: Total impurity 19.3 per cent; inert matter, 4.4 per cent; foreign seeds, 14.9 per cent. Noxious seeds: yellow foxtail, 298; pigweed, 51; paspalum sp. 43; sheep sorrel, 25; red-stem plantain, 25; smartweed, 14; curled dock, 12; bracted plantain, 10; black mustard, 8; parsley sp. 8; small crab grass, 7; charlock, 6; english plantain, 5; green foxtail, 4; grass sp. 4; five finger, 1; red-root, 1; hair grass, 1. Useful seeds: timothy, 146; alsike clover, 6; alfalfa, 6. There are 503 seeds of bad weeds in this sample, representatives of 18 different species. A pound of this clover would contain 59,310 foreign seeds.

son from the same market with price quoted. Comparing these we find that there was not a constant relation between price and purity. Thus, in each of six of these cases, samples were sent having the same price, the comparison follows:

The two samples on the same line are in each case from the same source.

VARIATION IN PURITY IN CLOVER SEEDS OF SAME PRICE FROM SAME SOURCE

Cleaner seeds			Dirtier seeds	
Price	Sample	Purity	Sample	Impurity
10 cts.	25	97.8%	26	92.6%
10 "	46	97.9 "	44	97.1 "
10 "	56	99.3 "	57	94.6 "
10 "	59	99.5 "	58	98.8 "
10 "	62	99.4 "	63	97.1 "
10 "	68	98.4 "	67	95.6 "
Averages,		98.7%		95.9%

From these figures it is evident that there may be a wide variation in the seed offered in the same market at the same price. If so, price alone is not a safe index to purity. This same fact is clearly shown in the further comparison of the remaining thirteen pairs of samples, where the two in each pair were from the same source but were of different price. The two samples on the same line of the following table are in each case from the same source. In each such pair the percentage of purity of the dirtier samples is in italics.

COMPARISON OF CLOVER SEEDS OF DIFFERENT PRICE FROM SAME SOURCE

Cheaper seed			Higher price seed		
Sample	Price	Purity	Sample	Price	Purity
4	8.5	*97.5%*	5	9	98.0%
7	8.5	96.7	8	12	*93.4*
11	9.0	*94.*	12	10	99.4
23	9.5	99.9	24	10	*99.7*
29	10.5	97.3	28	11	*96.4*
31	7.5	*93.8*	32	10.5	99.1
34	9.	*88.4*	33	10	*92.0*
37	9.	96.	35	10	*92.5*
43	9.	*95.3*	45	10	97.6
49	10.	*92.*	47	15	99.5
50	9.5	*98.3*	51	11	99.5
54	11.	97.3	55	12	*94.4*
62	10	99.4	61	11	*89.1*
Averages,	9.0 cts.	95.8%		10.9 cts.	96.2%

It will be seen from the last table that although there was on the, average a difference of nearly two cents a pound in the price, there was very

little difference in average purity, and that in six cases out of the thirteen, the higher price seed was the less pure.

To sum up the results from all these figures, it seems, therefore, that if one buys a low price clover seed, he is almost certain to get a dirty article, and that on the average he will purchase more seed for the same money by buying higher price goods. High price, however, does not necessarily mean pure seed, and therefore the purchaser must discriminatingly select his goods from among those of higher price. This requires critical examination under a magnifying glass, and most farmers are not provided with such a glass, or, if they are, they do not feel competent to use it. In this case they must either be satisfied to buy of a reliable dealer, depending upon his judgment and honesty, or they must submit samples to an expert for examination. A considerable number were sent to the experiment station last year, and the station is always ready to make such examinations and report results.

The only really satisfactory outcome will be when seedsmen furnish a definite statement of the percentage of pure and germinable seed in each lot offered for sale. This is entirely practicable, at least for such seeds as the grasses and clovers which are handled in large quantities.

A SOFT ROT OF CARROT AND OTHER VEGETABLES

Caused by *Bacillus carotovorus*, Jones[1]

Since much of this article is of interest only to the bacteriologist, and for purposes of reference, the following summary has been prepared. It is so paged that it will serve also as an index.

SUMMARY

I. Occurrence and character of the disease.—A rapid soft rot of carrots caused by a bacillus (*B. carotovorus*). General resemblance of disease to Heinz's white rot of hyacinth and to Potter's white rot of turnip, but organism not the same as either.—Pages 302–304.

II. Pathogenesis.—Disorganization of tissues apparently due to an enzym which softens middle lamellae. Wound infections led to decay in

1 Most of the study of this organism was made by the writer in the laboratory of plant pathology of the Division of vegetable physiology and pathology in the Department of agriculture at Washington. We are indebted to all of the officers of this division for many privileges extended and courtesies shown, and especially so to Dr. Erwin F. Smith who gave valuable advice and assistance in the details of the investigations.

The original publication of this species is expected to appear in Centrallblatt für Bakteriologie u. Parasitenkunde, 2te Abt. The proof of this article has not reached us at the time the present manuscript leaves our hands, therefore we cannot make the citation more exact.

roots of carrot, parsnip, turnip, radish, salsify, bulb and leaf of onion, leaf and scape of hyacinth, cabbage head, fruits of tomato, pepper, egg-plant. No decay resulted in young carrot or parsnip plants, or in ripe fruits of orange, banana, apple, pear, or in cauliflower head, Irish potato, beet root, tomato stem and petiole. No infection occurred where the epidermis was not broken. Character of decay in all cases similar : rapid softening of tissues, rate increasing with rise of temperature and abundance of water ; exudation of liquid clouded with bacteria ; no discoloration except browning of some carrots ; disagreeable odors from cruciferous plants and onion, little odor from other plants. —Pages 304–312.

III. MORPHOLOGICAL CHARACTERS OF ORGANISM.

1. *Form.*—A bacillus ; single in older cultures, chains or long filaments in young liquid cultures.—Page 312.

2. *Size.*—Individual rods in young cultures, 0.7–0.8 × 1.5–5 microns ; shorter and slightly narrower in old ones. Filaments 10–200 microns long. —Page 313.

3. *Grouping.*—Chains, filaments, small zoögloea masses ; little or no pellicle.—Page 313.

4. *Staining.*—Rather slow with aniline colors ; Loeffler's methylene blue stains well ; stains by Gram's method.—Page 313.

5. *Capsule.*—None observed.—Page 313.

6. *Flagella, motility.*—Motion vibratory, oscillating or darting in young liquid cultures, lost with age. Two to five peripheral flagella.—Pages 313–314.

7. *Spores.*—None demonstrated.—Page 314.

8. *Involution forms.*—Somewhat swollen, vacuolated rods occasionally seen.—Page 314.

IV. PHYSIOLOGICAL CHARACTERS OF THE ORGANISM.

A. CULTURAL CHARACTERS

1. *Nutrient broth.*—Clouding quick, moderate amount, uniform, persistent ; little or no pellicle or ring ; deposit gray-white, moderate.—Pages 314–315.

2. *Gelatin.*—Rapid surface liquefaction, slower in depths of stab ; copious white deposit ; slight pellicle formation. Buried colonies globose. Surface colonies white, circular ; magnified × 125, ciliate-fringed at margin on second or third day.—Pages 315–316.

3. *Agar.*—Buried colonies, × 125, white, oblong or spindle-form, margins irregular. Surface colonies, second day, round, elevated, smooth, gray-white, wet-shining ; magnified × 10 by transmitted light, slightly fluorescent and having transient flaky surface areolations ; × 125, margins sharply defined, entire or nearly so. In stab cultures slow growth along depths of stab. Slant cultures resemble surface colonies, showing thin

gray-white growth. No growth into agar; no discoloration. Crystals in old plate cultures.—Pages 316–318.

Carbohydrate agars.—Five percent additions of various carbohydrates inhibited earlier growth. Grape-sugar practically prevented all growth; milk-sugar gave slow but persistent growth; cane-sugar and glycerine gave greatly increased growth after the first week.—Pages 317–318.

4. *Milk.*—Acid formed; coagulation on fourth day; separation of whey; cheese-curd odor; no color.—Page 318.

5. *Blood-serum.*—No liquefaction; growth much like agar.—Page 319.

6. *Egg-albumen.*—No liquefaction; growth much like agar.—Page 319.

7. *Uschinsky's solution.*—Good growth; persistent clouding; fragile pellicle; copious white deposit.—Page 319.

8. *Dunham's peptone solution.*—Feeble persistent clouding; no pellicle; slight deposit.—Page 319.

9. *Cooked vegetables*, partially immersed in water.—

Carrot: Persistent clouding; thin white growth over exposed vegetable tissue; moderate amount of deposit and of gas; little or no pellicle; tissue softened; not discolored.

Potato: Deposit and surface growth on vegetable more copious than on carrot; slight softening and graying of potato; otherwise like carrot.

Various other vegetables gave similar results.—Pages 321–322.

B. BIOCHEMICAL RELATIONS

1. *Temperature relations.*—Optimum 27°–30° C. Maximum for growth 38° C. Death occurred in broth tubes heated 10 minutes at 51° C. Growth much retarded below 12° C.; no growth on vegetable media below 4° C., or on any medium at 1°.—Pages 322–323.

2. *Relation to free oxygen.*—Facultative anaerobe. Slight growth in favorable media in partial vacuum, in oxygen-free atmosphere (Buchner's method), in hydrogen and in carbon dioxide.—Pages 323–325.

3. *Production of acids and alkalies.*—Considerable acid produced in the presence of various carbohydrates, grape sugar especially favoring this. Litmus milk promptly reddened; rosolic-acid peptone bleached, color returning after three months; acid-fuchsin peptone slowly faded. Acids partly volatile, partly non-volatile. In 2 percent sugar-broth cultures acid development may destroy the organism. Slow alkali-production accompanied growth, and in the absence of carbohydrates medium became increasingly alkaline.—Pages 327–328.

4. *Relation of acids and alkalies to growth.*—Best growth in broth neutral to phenolpthalein; growth occurred in broth + 4.0 percent (malic acid) and —4.0 per cent, none in broth +6.0 per cent, doubtful growth on agar —8.0 per cent.—Page 328.

5. *Reduction processes.*—Litmus milk (coagulum) bleached from bottom upward. Methylene-blue-peptone solution not bleached, but bleached upon addition of 1 percent grape sugar. Nitrates in broth culture reduced to nitrites.—Pages 319, 320, 326.

6. *Indol.*—Moderate production in Dunham's solution, and in sugar-free broth.—Page 326.

7. *Hydrogen sulphide.*—Slight development from cultures in broth, on cooked potato and cooked turnip.—Pages 326–327.

8. *Odor.*—Little from most media ; offensive from cruciferous plants and onions.—Page 326.

9. *Desiccation.*—Drying for even a short time (2 minutes or less) at laboratory temperature was fatal.—Pages 328–329.

10. *Insolation.*—Ten minutes exposure of agar plates to direct sunlight was fatal, likewise two hours to diffused light. Ten seconds appreciably checked growth. Temperature 35°C.—Page 328.

11. *Gas-production.*—Moderate. With 2 percent broths, milk-sugar in fermentation tubes gave 15 per cent, cane-sugar 10 percent, mannit 8 per cent, grape-sugar 5 per cent, glycerine none. In all cases 20 percent of this gas was carbon-dioxide, 80 percent explosive.—Pages 329–330.

12. *Pigment-formation.*—None. Growth was of a white or delicate cream-white color upon all media.

V. REMEDIAL MEASURES.—Pages 330–332.

1. *Rotation of crops.*—Avoid susceptible plants for several years.

2. *Manuring.*—Avoid use of contaminated compost or manures for susceptible crops.

3. *Desiccation.*—Allow root surfaces to dry thoroughly before storage.

4. *Insolation.*—Allow harvested roots to lie as long as practicable, exposed to sunlight.

5. *Temperature.*—Hold storage room continuously at as low a temperature as practicable without freezing.

I. OCCURRENCE AND CHARACTERS OF THE DISEASE

In December, 1898, Mr. S. S. Chandler of Hardwick, Vt., advised the experiment station that he had suffered serious loss from rotting of his carrot crop for two successive seasons. Specimens of the diseased roots were sent, and examination of these indicated that the rot was of bacterial origin. Further investigations have shown that this was the case and that the organism causing this rot is capable of similar destruction of numerous other vegetables.

Mr. Chandler's experience was as follows : In 1897 he grew carrots on a field which had not been planted to this crop for many years, at least, and probably never before. Commercial fertilizers were used that year.

At harvest time he found occasional roots decayed. The roots were stored as usual in a cellar, whereupon the rot progressed rapidly. He had planned to keep the roots for feeding to his horses during the winter, but this threatening decay forced him to feed them out to other stock as quickly as possible. A portion of the manure produced by the stock so fed, was used upon the field where carrots were planted in 1898. He was is doubt as to the cause of this rot in 1897 and suspected that the roots might have been frosted.

His experience the second year, 1898, was similar to that of the first. There was a small amount of rotting observed in the field, and very serious decay began soon after storage of the roots. He was again forced to feed them out as rapidly as he could and, judging from the conditions in the few that he sorted out and attempted to, keep he would have lost every root if held until late winter. Mr. Chandler now suspected some specific disease and sent samples to the experiment station for examination.

Figure 1. CARROT ROT five days after inoculation at the crown. Shaded portion brown and much softened. Deeply shaded places above were irregular cavities resulting from exudation and evaporation of liquid and collapse of tissues.

In all cases these roots showed a rapidly progressing soft rot which had apparently begun either at the crown or at the root tip, and progressed most rapidly through the core. Upon cutting open such a root, the decayed portion was found to be softened and usually somewhat browned in color. There was a pretty sharp line of demarkation between the decayed and the sound tissues. Upon microsopical examination, the decaying tissues were found to be free from fungus invasion but to be swarming with bacteria. Such examinations and the making of poured plates showed that the recently decayed tissues contained practically pure cultures of a single organism. Sound carrot roots inoculated with this organism rapidly decayed and in such decaying tissues the original organism was again found to be present in nearly or quite pure cultures. It was considered certain, therefore, that the rot was due to a specific bacterium and a detailed study of this organism was undertaken.

There has been little opportunity for field observations in connection with this study and we are not able to say how general this or similar soft rots of carrots may be. Mr. Orton of Fairfax formerly grew considerable quantities of carrots and he tells us that while as a rule carrots have not rotted with him, yet he has at times had trouble with a soft rot which attacked the roots in the field, and did great damage there and later in the cellar. This would be serious for a year or two and then would not be noticed for sometime, when it would again occur. His description of the appearance and behavior of the rot agrees essentially with the characters of the disease under consideration.

It is well known that carrots are liable to decay badly at times in storage. Our observations have been too limited to justify the generalization that this particular organism is the cause of such carrot decays in all cases. We are, indeed, inclined to the opinion that other organisms may be found capable of doing similar injury to this root. Our results taken together with Mr. Chandler's experience do show, however, that this organism is capable of causing serious loss to the carrot grower, and indicate the wisdom of certain preventive measures where this form of rot occurs.

II. PATHOGENESIS OF THE ORGANISM

1. PATHOLOGICAL HISTOLOGY

Microscopic examination of decaying carrot tissues has shown that the organism invades the intercellular spaces and multiplies there with enormous rapidity. The middle lamellæ of the adjacent cells appears to be softened or destroyed by the excretions of the bacteria, since isolation of the cells in invaded tissue occurs much as when woody tissue is macerated in Schultze's solution. The protoplasm in such isolated cells is collapsed but the bacteria have not been observed within the interior of the cells of recently disorganized tissues. This breaking down of the intercellular substance is probably due to an enzym of the nature of cytase excreted by the bacteria and similar to that demonstrated by Potter in the case of his turnip rot organism.[1] Our own studies of this fermentive action have not as yet reached the point that justifies positive statements, however.

2. PATHOLOGICAL RELATIONS TO VARIOUS PLANTS

It has already been stated that inoculations of a pure culture of the organism into mature carrot roots have always caused the rapid decay of the root and that, in such decaying tissue, the organism has been found in

1 Potter M. C., On a Bacterial Disease—White Rot—of the Turnip. Proc. Univ. of Durham Phil. Soc., Nov., 1899.

nearly or quite pure culture. Similar tests have shown that it is capable of inducing decay in a considerable number and variety of vegetables and other plants under favorable conditions. The following were found to be thus susceptible and some of them proved to be nearly or quite as much so as the carrot root:—roots of turnip, ruta-baga, radish, salsify, parsnip, bulbs of onions, leaf-stalk of celery, leaves and scapes of hyacinth, fruits of tomato, egg-plant and pepper. Less rapid or less complete decay followed its inoculation into leaves and stems of stored cabbages and cut lettuce. There was no decay resulting from inoculations into the following:—ripe California naval orange, ripe banana, ripe apples (Golden Russet and Rambo), ripe pear (Winter Nellis), cauliflower, Irish potato,[1] sweet potato, beet and asparagus. Repeated inoculations, under varying and most favorable circumstances, were made into Irish potato tubers, but in no case was there any decay or other evidence of invasion by the organism. Slices of uncooked potato and also of beet and of sweet potato were placed in sterile petri dishes and inoculated, but in no case did growth of the organism or decay follow.[1]

Seedling plants of carrot and parsnip were grown in pots and these were inoculated when about four weeks old, both in leaves and roots. In no case did decay or other evidence of bacterial invasion follow in these young plants. Inoculations into the leaves and stems of young (half-grown) lettuce plants and into the petioles and stems of tomato plants likewise gave negative results.

3. DETAILED METHODS OF INOCULATIONS

Most of these inoculations were made in winter (February to April). In such the roots and fruits were obtained fresh from the market and fresh sound specimens were selected. The method of inoculation generally practiced with roots (carrot, beet, turnip, salsify, radish) was to wash them in distilled water, then immerse for from ten to thirty minutes in a 0.1 percent solution of mercuric chloride to free them from surface organisms. Experience showed that this latter precaution was unnecessary, however, and some of the later inoculations were made into washed but unsterilized roots.

In the earlier inoculations with fruits (apple, pear, banana, tomato, egg-plant and also with onion bulbs) a small area on the surface was rendered sterile by pressing a hot knife blade upon it for a moment, the subsequent inoculation being made by needle prick or scalpel thrust at the center of this area. This method was considered open to the objection

1 Just as this manuscript is leaving our hands, we find that decay has resulted from inoculations into slices of sterile, uncooked potato in a petri dish. Since numerous trials, made previously by the same method, have failed, we conclude that the tuber used at this time was peculiarly susceptible.

that it killed the surface cells and in all cases except egg-plant, where such inoculations led to decay, subsequent inoculations were made without such injury to the surface. In all these reinoculations, the results were similar to the earlier ones, that is the decay was induced.

In the leafy plants (lettuce, cabbage, celery, hyacinth,) the only precaution was to select clean specimens and to rinse the plants thoroughly in distilled water. In these cases there was, of course, greater possibility of the introduction of surface germs along with the organism inoculated. As a partial check upon this method, therefore, other wounds were made with a sterile scalpel or needle and of the same extent as those made in the corresponding inoculations and these wounds were moistened by a drop of sterile water. In this way surface germs were given quite as favorable opportunity for entrance as at the point of inoculation, but in no such case was there any decay or other evidence of bacterial invasion.

The inoculations were made by transferring a two or three millimeter loop of broth, or other liquid culture, to the surface of those plants not disinfected, and stabbing through this a short distance into the underlying tissues with a flamed needle, or opening a slit in the surface with a sterile scalpel and introducing a loop of the culture into this wound. In case of roots which had been disinfected by immersion in corrosive sublimate, a surface layer of tissue was frequently removed from a small area (about 5 mm. in diameter) by means of a sterile knife and the inoculation was made into the center of this freshly exposed tissue. In all cases, therefore, the inoculations amounted to wound infections.

Several trials were made by simply placing drops of the fluid culture upon the uninjured surface of susceptible plants (celery and carrot) but in no case did infection result. These observations indicate that the organism cannot ordinarily make its way through the uninjured cuticle.

In the case of hyacinths and celery, however, where a decaying leaf lay in a moist chamber in immediate contact with a healthy leaf, the decay quickly invaded the latter.

Sterile slices of uncooked vegetables afforded opportunity for more exact observations than did the entire roots and were much employed in these studies. They were prepared by washing and peeling the vegetable (potato, carrot root, etc.) rinsing this through several distilled waters and then either flaming the surface or immersing from ten to thirty minutes in 0.1 percent solution of mercuric chloride. In the earlier work, the roots were then washed and precautions were taken to remove the surface layers which might contain corrosive sublimate, cutting slices from the core only. Later it was found that by properly drying the roots so that no solution flowed over the cut surface, the slices could be used without such precautions. In all cases slices 1 cm. or less in thickness were cut from the disinfected vegetable, with precautions against air contaminations, and these

slices placed in sterile petri dishes. These were usually incubated 24 hours at 35°–37° C. to test their sterility, before use for inoculations.

These petri dishes after inoculation were in all cases held at laboratory temperatures (20°–25° C.) The same was true of the roots and other vegetables unless otherwise stated.

The whole roots were loosely placed in an uncovered jar in most cases. In some of the later experiments, placing them in covered dishes so as to lessen evaporation, was found to hasten the earlier stages of the invasion, but did not otherwise alter the results. The fruits, leafy plants, and bulbs, except those of growing plants, were in most cases kept in a partially closed vessel at laboratory temperature (20°–25° C.) or in a chamber connected with a refrigerator (moist atmosphere, temperature 15°–20° C.) In some cases they were simply wrapped in paper as will be explained in discussing the results

4. DETAILED RESULTS OF INOCULATIONS

Carrot roots.—Detailed observations and records were made during the earlier studies upon some twenty whole roots inoculated at several different times, uninoculated checks being held in all cases. In every case the characteristic decay has promptly followed inoculation and no decay has occurred in any check. At least as many more roots have since been inoculated with like results. Both long orange and half-long varieties have been included.

Fig. 2. CARROT ROOT
Ten days after inoculation at the crown. The decay was confined to the core owing to the drier condition of the outer tissues. Compare with figure 1.

The first evidence of invasion following the inoculation into carrot root, was a water soaked appearance of the tissues immediately about the wound. This was apparent in from 18 to 36 hours, temperature 20°–24°C. During the next day or two there was evidence of the breaking down of the tissues at the point of inoculation, often accompanied by the exudation of drops of light gray liquid, swarming with the bacillus. If the roots were exposed to the dry air of the laboratory the breaking down of the cellular structure and the evaporation of this liquid usually led to the formation within the root of an irregular and gradually enlarging cavity bordered by the more recently decayed tissues, see figure 1. When in from one to two weeks, the roots were cut open for examination, it was found that the decay had involved from one-fourth to the whole of the inte-

rior of roots kept at 20°–24°C. Poured plates were made from several of these roots, and in all such cases the original organism was found in nearly or quite pure cultures. The decay usually proceeded at a uniform rate through the different tissues of the root. Where there was any difference it was associated with varying water content, the organism invading the moisture tissues more rapidly, see figure 2.

Inoculations were made upon hundreds of slices of sterile uncooked carrot in petri dishes. (See methods, page 306.) In every case they were rapidly rotted. When a 2 mm. oese of broth or similar culture was placed on the surface of such a slice, there resulted a water soaked appearance of the underlying tissues in from 6 to 12 hours at 20° to 23°C. In 24 hours this area enlarged to a diameter of from 1 to 2 cm. Frequently at this stage water, drawn from the interior of the root, formed a large drop on the center of the decaying spot. Such drops were milky with bacterial growth and were, doubtless, drawn to the surface by the osmotic action of the products of such growth. Frequently where no such drop was formed there was a delicate moist gray bacterial film over the invaded surface. The surface growth was never conspicuous, however, and in many cases was not apparent.

The invaded areas were rapidly softened, and as a result of this, together with the loss of water cracks opened through them, as shown in figure 3.

Fig. 3. CARROT CULTURES

Showing appearance of uncooked slices of the root in a petri dish culture six days old. The left upper piece was not inoculated; the others were. The drawings indicate the discoloration and disorganization which resulted.

The tissues of half-long orange roots usually turned brown or nearly black (sepia), as a result of the invasion of the organism, this discoloration beginning within twenty-four hours. In long orange roots, on the contrary, there was no discoloration, or it was but slight and slower in appearing. It was suspected at first that this difference in discoloration of these roots was due to difference in their tannin content. In order to see if this explanation was correct, roots of each of these two varieties were obtained from several sources, extracts of these were made separately by macerating 5 grams of the fresh root in 100 cc. of water and allowing to stand in the refrigerator 24 hours. This extract was then tested for tannin but practically none was found in any case. Tests with solutions of gum guac showed,

however, a marked difference in the amount of oxydyzing enzyms[1] or oxydases present, the half-long orange roots containing much more of the enzym than did the long orange varieties. There was, however, evidence of the presence of oxydase in the long orange roots in sufficient quantity to produce a slow discoloration if there was an oxydizable substance to act upon. Since no such discoloration appeared as a rule, even on long standing, it was concluded that the difference in discoloration was due to the presence, in the half-long varieties, of this relatively larger content of oxydazes, together with some easily oxidizable chromogen other than tannin.

Parsnip roots.—Several roots were inoculated at different times. In all cases except one, the inoculations were made into moist solid tissue and the decay quickly followed. In one root the inoculation was made into the core at the butt end and it failed. Examination later showed that the core tissues here were dry and pithy and the failure was evidently due to this lack of moisture.

Pieces of uncooked parsnip root in sterile petri dishes, upon inoculation, were invaded and rotted about as rapidly as similar slices of carrot. The invaded tissues were changed to a clay color at first soon deepening into a cinnamon-brown.

Cruciferous roots.—Roots of turnip, ruta baga and radish were inoculated and numerous slices of the uncooked roots were tested in sterile petri dishes as in the case of carrot and parsnip. Under both methods of trial, the organism invaded the tissues even more rapidly than it did those of the carrot or parsnip. In globe turnip at laboratory temperature, the decay involved a circle about the point of inoculation of 1 cm. in diameter at the end of the second day. On the fifth day the entire root was soft and pulpy so that it could not sustain its own weight. Average size table radishes were completely rotted on the third day after inoculation. There was no marked change of color in any of these roots, the invasion being at first indicated by the water soaked appearance of the tissues and, immediately following this, by their softening and disorganization. The decay of these cruciferous plants was accompanied by an offensive odor (mercaptan ?)

Cabbage.—Inoculations made by needle stabs through the thin overlapping leaf-blades at the top of cabbage heads did not induce decay, but prompt invasion followed stab inoculation into the more solid and presumably moister tissues of the stem or fleshy petoiles at the under side of the head. The decay thus started spread pretty rapidly so that the entire head would usually be involved in a week or two at laboratory temperatures (20°–25°C.) The amount of decay occurring in four days is shown in figure 4. It was of course impossible to sterilize the entire cabbage head. Care

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1 Much assistance was secured in connection with these tests from Dr. Oscar Loew and Mr. A. F. Woods, to whom I am also indebted for advice regarding other matters.

was taken to have the inoculated surface sterile and the earlier decay was certainly due to the carrot rot organism. In the later stages, other organisms doubtless played some part.

Cauliflower.—Two inoculations were made into cauliflower stems under favorable conditions for the growth of the organism (moist chamber, temperature 20°–25°C) but no decay resulted.

Celery.—Five bunches of celery were inoculated at different times, the inoculations usually being made into several of the young blanched leaf stalks in each bunch. In some cases the bunch was kept in a moist chamber, in some it was wrapped in paper and placed on a shelf in the laboratory. With one exception every stalk inoculated quickly decayed. In this one case the inoculation was into an outer partly green leaf-stalk where the tissues were quite dry and fibrous. In the case of the plants wrapped in a paper and kept on a shelf in the laboratory, the wrapping was insufficient to keep the outer leaves from wilting, yet the decay advanced through the young blanched leaf-stalk, at the rate of 5 cm. in 24 hours. The rate of decay was even more rapid in the moist chamber where a leaf-stalk 25 cm. long was invaded and rotted in two days. The decaying tissues emitted a peculiar sweetish and unpleasant odor. The rot did not invade the tissues of the stem or "crown" even under the most favorable circumstances and when inoculated freely.

Salsify.—Two roots of this plant decayed when inoculated in the crown but did so less rapidly than did carrot or turnip. The decay advanced faster in the vascular ring than in the adjacent parenchyma.

Onions.—Six mature bulbs were inoculated by pricks or stabs into the outer scales, uninoculated checks being held in each case. In every case decay followed promptly. The advance was about twice as rapid at a temperature of 20°–23°C, as it was in a cool compartment of the refrigerator (16°–20°C.). It was noticeable that while the decay progressed rapidly through the scale lengthwise and around the bulb, it passed more slowly from scale to scale. In one case an inoculated bulb lay in a cool box two months. The outer scales, comprising nine-tenths of the bulk of the bulb, decayed promptly but the decay was so slow in reaching the heart of the bulb that several long healthy sprouts were thrown out. Finally two of these sprouts were inoculated each by a single needle prick. Decay was evident at the point of inoculation in 24 hours, and within a week these shoots were entirely rotted. It is probable, therefore, that their long escape was due to the fact that their uninjured epidermal layers presented an effective barrier to the entrance of the germs. Three young table onions from the market were inoculated and decayed very rapidly, and similarly to the mature bulbs. These decaying onion tissues in all cases emitted an offensive odor.

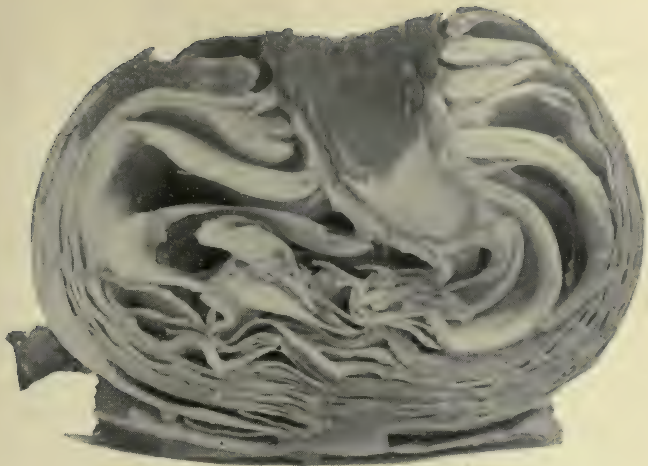

Figure 4. DECAY IN CABBAGE

Showing the extent of the rot on the fourth day after a needle stab inoculation into the base of the stem with a pure broth culture of *Bacillus carotovorus*. Kept in a moist atmosphere, at 20°–22° C. The more darkly colored portions of the stem and of the base of the leaf at the left were entirely softened. Inoculation and photograph made by F. R. Pember. Reduced ×½.

Figure 5. DECAY IN GREEN TOMATO

Fruit clinging to parent plant in the garden in August. Inoculated by needle stab four days previously with a pure broth culture of *Bacillus carotovorus*. Photograph, natural size.

Hyacinth.—The leaves and scapes of potted plants of Dutch hyacinth, in the flowering stage, decayed rapidly where inoculated in the younger and moister tissues near the base. These plants stood uncovered in the laboratory, at 20°–23°C. Similar inoculations into the dryer and older tissues near the summit of the scape or above the middle of leaves, failed to cause serious decay in all cases where the plants remained exposed to the dry air of the laboratory. In these the decay usually started and made slow progress for a day or two, then ceased and the spots dried out. In several cases the same leaves and scapes were later reinoculated near the base and active decay followed. This difference in behavior was attributed to the difference in the water content of these basal tissues since in later trials when the plants were covered with a bell-jar, rapid decay followed inoculation in the upper, less watery, leaf tissues. When the decay was once started it progressed very rapidly, in some cases (in a moist chamber) spreading across the leaf and involving 3 to 5 cm. in length in a single day.

Fruits of tomato, egg-plant and pepper.—All were found to be very susceptible to this organism. Inoculations were made both into green and into ripe fruits of tomato and pepper, and into ripe egg-plant. The results were practically alike in all cases, viz: rapid soft decay, *but progressing more rapidly in the green fruits than in the ripe ones.* Green peppers inoculated and placed in a cool chamber at 18°C. were entirely decayed in eight days. In green tomatoes, under similar circumstances, the decay was quite as rapid. In each case it was considerably less rapid in the ripe fruits inoculated at the same time and kept under similar conditions. Inoculations of tomatoes still on the growing plants in the green-house in April and in the open garden in August, gave similar results, viz: decay of fruit in all cases but more rapid in green than in ripe fruits. The progress of the decay was as follows (green-house plants in April): Hard, green, half-grown fruit inoculated by a single needle prick to a depth of 2 or 3 mm., showed in 24 hours a slight water-soaked appearance about the point of inoculation. On the second day this area was 3-5 mm. in diameter, dark-colored, somewhat sunken, and when on the lower side of the fruit there was slight oozing of gray liquid from the needle puncture. The progress of the decay thereafter was rapid until in from a week to ten days the entire fruit was involved and usually dropped from the stem. In the more rapidly

Fig. 6. YOUNG TOMATO
Clinging to parent plant in green-house (April). Shaded area shows the extent of the decay at the surface on the third day after a needle-stab inoculation. Natural size.

growing fruits in the garden, in August, cracks usually opened through the area of decay after three or four days, and the decay was even more rapid than in the green-house, see figure 5. When inoculated green tomatoes were kept in a moist chamber at the laboratory temperature (20°–24°C.) the decay was similar but more rapid. An inoculation into a single egg-plant fruit from the market led to similar decay. It was not possible to try inoculations upon either pepper or egg-plant fruits on growing plants, but the behavior of the growing tomato leads to the opinion that fruits of egg-plant and pepper clinging to the parent plant, would decay in the same way.

Inoculations have been made into carrots, tomatoes and other vegetables, using cultures which had been developed continuously upon agar or in broth for over a year. The decay was prompt, showing that the bacillus does not lose its pathogenic powers by such cultivation.

5. COMPARISON WITH OTHER PATHOGENICALLY SIMILAR ORGANISMS

As will be seen from the preceding results, this bacillus resembles, in its pathogenesis, Heinz's *Bacillus hyacinthi septicus*[1], which causes a soft white rot of the hyacinth and also Potter's *Pseudomonas destructans*[2] which causes a soft white rot of turnip. It differs from Heinz's organism, however, since that does not liquefy gelatin while this one is a rapid liquefier. Potter's organism has a single polar flagellum (*Pseudomonas*) whereas this has several peripherally disposed flagella. It seems probable that further study of the bacteria concerned with the soft rots of plants will swell the list to a considerable number of organisms which resemble the above and each other more or less closely in their physiological characters. Indeed, it would not be strange if such studies reveal a considerable group or number of groups of closely related organisms whose differentation will tax the skill and patience of the bacteriologist as much as has the attempt to exactly define the relationships of members of the *B. coli* group.

III. MORPHOLOGICAL CHARACTERS[3]

1. *Form.*—A bacillus with rounded ends occurring singly or rarely in pairs in old agar and nutrient broth cultures, but frequently in pairs or chains of several cells or in filaments in young cultures (24–48 hours) in nutrient broth and other liquids. In young agar cultures (24–48 hours, temperatures 22°–25° C.) these chains and filaments were better developed and often reached a length of 100 to 200 microns or more.

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1 Heinz, A. Centrallblatt f. Bakt. u. Parasitenkunde, Bd. V. pp. 535–539, (1889).

2 See footnote page 304.

3 Zeiss 2mm oil-immersion lens and compensating oculars 6 to 12 were used in the more exacting of these studies.

2. *Dimensions.*—(*a*) Diameter: Broth culture, 24 hours growth at 22°-25°C, stained in fresh, cold, watery solution of fuchsin, showed extremes 0.6 to 0.9 microns, four-fifths of the rods being between 0.7 and 0.8 microns. Agar culture 24–36 hours, 28°-33° C, stained in fresh, cold, watery solution methyl violet showed 0.6 to 0.8 microns. Old cultures (agar 20 days) were slightly narrower, 0.6–0.7 microns.

(*b*) Length: Broth cultures, 24 hours growth at 22°–25° C, cells 1.5 to 5 microns averaging 2.8 microns; many pairs and some longer chains and filaments. Agar cultures 24-36 hours, 28°–33° C, showed many distinct rods of similar length (1.25 to 4 microns) along with chains and filaments frequently reaching a length of 50 to 100 microns or more. Agar culture 20 days old, rods mostly distinct, 1.5 to 3 microns long. Numerous measurements made of hanging drop preparations and of those stained in other ways did not differ essentially from the above.

3. *Grouping.*—The formation of chains and filaments has been noted above. Zoögloea masses 25 microns or more in diameter occurred frequently in young growth (24 hours) in broth and other liquid cultures.

4. *Staining powers.*[1]—The bacillus takes the watery aniline stains so far as tried but with many of them it stains rather slowly. Good results were secured by from 5 to 10 minutes staining in watery solutions of fuchsin, gentian violet, methyl-violet and methyl-blue; carbol-fuchsin stains quickly and deeply; 5 minutes in Loeffler's aniline methylene blue; gave good stain; the organism is also stained by Gram's method.

5. *Capsule.*—No evidence of any was observed with the above stains.

Fig. 7. BACILIUS CAROTOVORUS
Flagella stained by Löwits' method.

6. *Motility and Flagella.*—Active motility occurred in beef broth, vegetable broth and other liquid cultures during the first few days (20°—30° C), but older cultures showed less activity. In freshly invaded carrot tissues, the organisms were very actively motile. The movements of single rods were usually vibratory although in active young cultures direct or darting movements were frequent. Many of the chains or filaments when these occurred showed active vibratory or serpentine movements.

Preparations from young agar (24 hour) cultures were stained by van Ermengem's nitrate of silver method for flagella with rather unsatisfactory results, but excellent stains were secured by Löwits' method with

1 Grübler's stains were used in all cases.

the more actively motile organisms from young carrot broth cultures. These showed each rod to have from two to five peripheral flagella, figures 7 and 8. In the agar cultures the flagella were 6 microns or less in length, but in the carrot broth cultures their length was greater, often 10 microns or more.

7. *Spores.*—In no case has there been any evidence of spore-formation, although diligent microscopic search has been made in cultures of various ages and upon various media, (agar, gelatin, broth, potato, carrot). Many such cultures have been subjected to the thermal test but exposure to a temperature above 55° C. has killed all of the organisms in every tube tried.

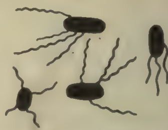

Fig. 8. BACILLUS CARTOVORUS

Flagella, stained by van Ermengam process.

8. *Involution forms.*—Peculiar forms differing from the normal, have been observed in a few cases. In carrot cylinder[1] cultures two months old, a considerable number of the rods have been observed to show refractive oval areas in the interior. The appearance of these suggested spores, but they refused to take spore stains and these cultures were killed by heating 10 minutes at 75° C. (lower temperatures were not tried. These were interpreted therefore as vacuolated rods. Similar vacuoles occupying swollen areas in rods have occasionally been observed in young (1–3 day) agar cultures. In the latter these peculiar rods were often quite actively motile, and exposure to 55° C for ten minutes killed them.

IV. PHYSIOLOGICAL CHARACTERS

1. CULTURAL CHARACTERS ON VARIOUS MEDIA

The culture media used were prepared with much care, following closely the methods of the Procedures recommended for the study of bacteria of the American public health association[2]. Distilled water was always used, and nearly all the chemicals were c. p. The nutrient broths were prepared from lean beef and reactions of media determined by titration with phenolphtalein.[3]

Nutrient broth.—Rapid growth in broths ranging from zero to +1.7 per cent. For example, zero broth, 10 cc. per tube, inoculated with 1 mm. oese, 28°-30°C., perceptibly clouded in five and a half hours.

At laboratory temperatures (22°-30°C.) the liquid becomes semi-opaque from clouding in 24 hours, cloudiness slowly increases for several days, then

1 See details of vegetable cylinder cultures later.

2 Report submitted at the meeting of the Association in Philadelphia, September, 1897.

3 The reaction of the medium is stated in the percent of n/1 alkali or acid required to render it neutral to phenolphtalein. Acidity is indicated by the + sign, alkalinity by the − sign.

remains without much change for a long time, tubes three months old being still well clouded. If undisturbed a delicate incomplete pellicle develops, which readily breaks up and settles upon agitation, leaving a faint incomplete ring easily washed away.

A slight grayish white precipitate appears on the second day and slowly increases until ultimately (three months) it amounts to one per cent of the original volume of the medium. Reactions of cultures in broth originally slightly alkaline to litmus (+1.5 per cent) as determined by neutral litmus paper were as follows:

At end of each 2, 5, 10, and 12 days feebly acid.

At end of each 18 and 25 days feebly alkaline.

At end of 53 days, strongly alkaline.

At end of three months, more strongly alkaline.

Titration of such a broth culture one month old showed the reaction to be —1.0 per cent.

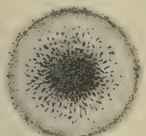

Fig. 9.
GELATIN COLONY
Surface of plate culture, 48 hours old, as seen under magnification x 125, drawing reduced to x 10.

GELATIN.—The organism grows well on gelatin and liquefies it rapidly.

Colonies.—Plate cultures, reactions +2.0 per cent, 20°-21°C., colonies apparent on second day. Viewed under a magnification of 125 diameters the buried colonies were at first spherical, uniformly granular, margins sharply defined. In most cases this sharp outline was soon lost, the body of the colony becoming surrounded by a faint halo of organisms scattered through the surrounding gelatin. This apparance was apparently associated with the early stages of liquefaction of the gelatin. Such colonies then rapidly enlarged in size and soon reached the surface. Those that failed to do so after two or three days showed concentric zones with a radiating fringe-like growth at margins as described later in the surface colonies.

Surface colonies.—Were uniformly granular at first (under Zeiss 16 mm. objective and 8 ocular) but soon so liquefied the gelatin as to form a funnel shape cavity and the collection of the precipitate at the bottom of this formed a gray-white nuclear mass. This was usually dense and opaque at the center surrounded by detached irregular flaky masses as shown in figure 9. The liquefied gelatin surrounding this was uniformly granular and showed a denser rim bordered externally by a fringe of delicate indistinctly radiating fibrils. This fringe is due to bacterial growth radiating from the body of the colony into the surrounding unliquefied gelatin. Its width varied with temperature, but in plates held at 20°-22° C. averaged about 50 microns on the second and third days of growth.

Stab cultures.—Growth developed the full length of the stab, but was more rapid in the upper portion. Liquefaction first appeared at the surface

and led to the formation of a broad shallow funnel as shown in figure 10. Liquefaction extended quite across the surface before reaching far into the depths of the tubes, but ultimately the medium was entirely liquefied. No gas bubbles were observed in gelatin. A fragile and imperfect white pellicle was formed in the liquefied tubes and an abundant white precipitate, its volume amounting to two or three times that formed in broth. Liquefied tubes, 41 days old, were strongly alkaline to litmus paper.

Growth upon sugar-gelatins.—Stab cultures were made into tubes containing respectively 5 percent cane-sugar gelatin, 10 percent of cane-sugar gelatin, 5 percent grape-sugar gelatin, 10 per cent grape-sugar gelatin. These were held at temperatures of 16°–22° C, for seven days. There was a slow growth in all of these, with some liquefaction in the cane sugars, but much less rapid than in the plain gelatin. The growth in the grape sugar media was about one-fourth of that in the cane-sugar, and there was no liquefaction.

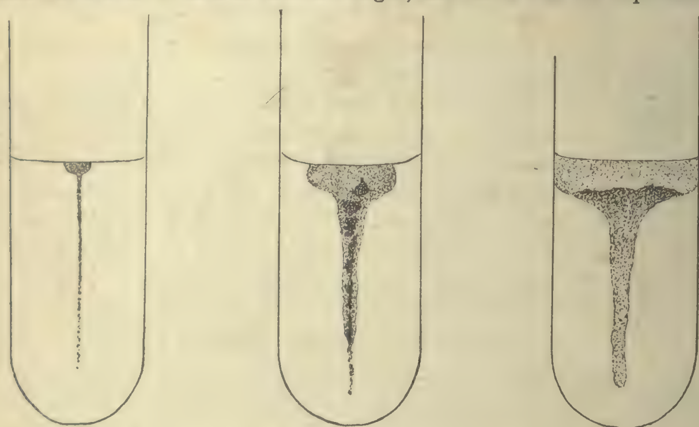

Fig. 10. GELATIN STAB CULTURES

The first, 24 hours at 20 degrees; the second, 48 hours at 20 degrees; the third, 7 days at 15 degrees, equivalent to 3 days at 20 degrees.

AGAR.—Good growth on agar of reaction +1.5 percent. In plate cultures colonies were visible on the second day (30 to 40 hours) at temperatures of 22°–25° C.

Buried colonies under magnification 125 diameters, varied in outline from globose to oblong and spindle shape, with irregular margins.

Surface colonies were gray-white with a slightly elevated, smooth, wet-shining surface. With a good hand lens (magnifying 10-15 diameters), young colonies, 40 to 50 hours old, showed a characteristic appearance, best seen against a dark back-ground. They were at this stage scarcely opaque and had peculiar flaky or areolated surface markings as shown in figure 11. These were transient, usually disappearing within 24 hours, and

thereafter the colonies appeared uniformly granular under such magnifications. This flaky appearance of the young colonies has been observed in some other species so that it has not great value as a differential character however. It is doubtless due to the formation of a delicate surface pellicle which is ruptured by the subsequent growth of the colony into the irregular more or less concentrically arranged fragments observed. Under magnification of 125 diameters, this flaky character is not apparent by transmitted light but is so by reflected light. The margins were sharply defined and entire or slightly crenate for the first day or two but usually became indistinct with age.

Fig. 11. AGAR COLONY Surface of plate culture, 48 hours growth, x 10.

Agar streaks show good growth within 24 hours, 22°–28° C. Margins sharply defined and entire in earlier growth becoming crenate or irregularly lobed after a day or two, slightly elevated, wet-shining, gray-white, no discoloration of agar or tendency to grow into it. Dense clouding and rather copious deposit in condensation water.

Agar stabs showed slight growth along full depth of stab, but decreasing toward bottom. Growth spread rather slowly over the surface as a slightly elevated, wet-shining layer with crenulate margins which ultimately reached nearly or quite to walls of tube. Gas bubbles were rarely observed in plain agar stabs, but were formed in shaken agar tubes, see p. 318. No lateral outgrowths from the stab into the agar were observed. Agar was not discolored. Crystals were abundant in agar plate cultures four weeks old. (ammonium phosphate ?).

Carbohydrate agars.—Cultures were made in agars containing respectively 5 percent additions of the following carbohydrates: cane-sugar, grape-sugar, milk-sugar, mannit, glycerine (reactions +1.5 percent).

In every case the earlier growth was retarded by such addition. With the grape-sugar this retardation was so great that heavy and sometimes repeated inoculation was necessary to get a growth started. In milk-sugar the effect was similar but less pronounced. Thus in a typical series the relative growth at the end of the second day taking the plain agar as the basis of comparison was: plain agar, 100 per cent; cane-sugar agar, 75 per cent; glycerine agar 65 per cent; milk-sugar agar 0; grape-sugar 0. In the same series on the fourth day the growth on the cane-sugar and glycerine agars was equal to that on the plain agar, while on the milk-sugar a few isolated colonies were appearing. At the end of one month the growth on cane and milk-sugars and glycerine much exceeded that on plain agar. That on the glycerine agar formed a thick semi-opaque, creamy-white, wet-shining layer covering the entire surface of the slant. That on the cane-sugar agar was similar but thinner and not fully covering the upper surface of the slant, estimated at 60 per cent of that on glycerine. On milk-sugar agar the character of growth was again similar to glycerine but only the lower

half of the slant was covered, amount estimated at 40 per cent of that on glycerine. On the plain agar the growth was not over one-half as thick as the preceding, estimated at 25 per cent of that on the glycerine. There was no growth on the grape-sugar agar in this series, and in other cases where it did get started, it made but feeble growth.

Gas formation in agar.—This was tested with the plain agar, and for agars containing 5 per cent additions of each of the following carbohydrates: cane-sugar, grape-sugar, mannit, glycerine. The method employed was to transfer a 2 mm. loop from a young broth culture to a melted agar tube (40°C) shake thoroughly and allow to stand at room temperature, 23°-28°C. Upon the second day numerous gas bubbles were developed in the plain agar tubes, fewer in the glycerine and mannit, and very few and small ones or none at all in the cane and grape sugars.

Milk.—Ten cc. tubes of fresh milk, amphoteric to neutral litmus paper, + 1.7 to + 2.0 percent, inoculated with 1 mm. loops from broth cultures and held at 23°-26° C. showed no visible change for three days. On the third day the milk was distinctly acid and thereafter remained so. On the fourth day curdling occurred. Heavier inoculations (2 mm. loop) led to curdling on the third day, in irregular masses and coarse granules. The curd was rather soft at first but became firmer on long standing. It was smooth and free from gas bubbles, and when fully settled occupied about one-third the depths of the medium. The whey promptly separated from the curd but remained rather turbid even after standing some weeks. The older milk cultures had a distinct and agreeable odor of cheese curd. Upon heating such above the thermal death point of the organism, and tasting, there was a decided cheese-curd flavor, not wholly agreeable, but not bitter. No color was developed at any time.

Fermentation tube cultures of milk gave no gas in the closed end. Upon emptying at the end of two weeks the milk was found to be only partly curdled in the closed end, but upon heating in boiling water the curdling was immediately completed. Inasmuch as other experiments showed the organism to be easily killed by its own acid products, various milk cultures were tested for viability, with the following results: one culture 11 days old alive; one culture 25 days old dead; one culture 35 days old dead; another 35 days old alive, but slow in developing, evidently living organisms very few and feeble; culture 3 months old dead. Distillation of acid milk cultures showed the presence of both volatile and non-volatile acids.

Litmus milk.—(Fresh amphoteric milk plus 5 percent saturated watery solution dry litmus). Distinct reddening within 24-48 hours (20°-24° C.), color slowly deepening to purple. Casein was precipitated as in milk, but somewhat more tardily. Bleaching began in 7 to 10 days and was completed in about three days thereafter. Steaming the bleached tubes to kill

the organism was followed by return of red color within a week. In unsteamed tubes this return of color occurred in two or three weeks.

Loeffler's blood serum.—(Calf's blood). Surface streak cultures made good growth, smooth, white, moist, resembling that on agar slants, but no liquefication, and no discoloration of the medium during two months at temperature 22°-25° C.

Egg albumen.—White of egg coagulated and sterilized by heating at 80°-90° C. for two hours on each of three successive days. Growth on slants of this medium in general resembled those on blood serum ; no liquification, no staining of substratum.

Uschinsky's solution, proved an excellent medium for this organism. Distinct growth appeared in tubes within 24 hours, at 22°–24° C. This consisted of a delicate surface pellicle at first which was very fragile and upon the slightest agitation was precipitated or diffused. There was uniform clouding after the second day although the most active growth continued at the surface with pellicle formation for a month or more followed by a gradual loss of cloudiness in the upper layers. There was a copious white deposit amounting, in cultures a month or more old, to 20 percent of the original volume of the medium, which was fifteen or twenty times the precipitate formed in broth cultures.

The reaction of Uschinsky solution cultures to neutral litmus paper was as follows : sterile medium, faintly acid ; well clouded cultures, three, five and twelve days old, all faintly acid, acidity decreasing slightly with age ; cultures two months old more strongly acid than was the original medium.

Dunham's peptone solution.—(One percent Witte's peptone, 0.5 percent c. p. sodium chloride). In this but feeble growth was made. Faint, uniform clouding occurred in 24 hours (22°-25° C.), which increased but slowly and never became heavy ; persistent for two months and probably much longer ; no pellicle or ring ; precipitate very slight, estimated at one per cent of that in nutrient broth.

Reactions to neutral litmus paper :—sterile medium faintly alkaline ; cultures four days old showed no change in alkalinity, but older ones (five weeks) showed distinctly stronger alkaline reaction.

Dunham's solution was used as a basis for several other synthetic media as follows :

Methylene-blue peptone.—(Dunham's solution plus two percent of a 0.1 per cent aqueous solution of methylene blue). Growth as in simple Dunham's solution. No reduction of color during three months growth. Upon this medium with the further addition of one percent grape sugar the growth was more vigorous as shown by heavier clouding ; at the end of 24 hours the blue color was reduced to one-third of the original depth and remained so until the third day when it returned. Litmus paper tests on

the sixth day showed the medium decidedly acid, on the ninth day the tubes were free from cloudiness and transfers then showed them to be sterile. The organisms were evidently destroyed by their own acid products. Distillation of this acid medium showed the presence of both a volatile (carbon dioxide?) and a non-volatile acid.

Indigo-carmine peptone.—(Dunham's solution plus two percent of a 0.5 percent aqueous solution of indigo-carmine). Medium not used until several days after making; growth as in simple Dunham's solution. Both the inoculated and the uninoculated check tubes continued to bleach until all color was lost and it did not return. Reactions to litmus paper as in Dunham's solution. Where one percent of grape sugar was added to the above medium there was more vigorous growth and development of acidity, followed by the loss of cloudiness and the death of the organism as in the tubes of methylene-blue peptone solution with grape sugar.

Rosolic acid peptone.—(Dunham's solution plus one percent of the following: 0.5 g. rosolic acid, 20 cc. distilled water, 80 cc. absolute alcohol). Since the alkalinity gave this solution a deep salmon color, one drop of double normal hydrochloric acid was added to 20 cc. of the medium, reducing it to a pale salmon color. This color began to fade on the second day after inoculation and entirely disappeared within a few days. The cultures remained colorless for nearly three months, when they slowly became pink-red and this color persisted. These changes showed the slow formation of acid in the earlier stages of the growth neutralized by very slow alkali formation later.

Acid fuchsin peptone.—(Dunham's solution plus two percent of a solution of 10 mg. Grübler's acid fuchsin, after Weigert, in 30 cc. water; added one drop of double normal hydrochloric acid per 20 cc. of medium, reducing color to deep red). During the first month there was the feeble growth characteristic of Dunham's solution cultures, but no change of color; at the end of the second month the color had faded to one-half the depth of the sterile check tubes and the cultures were still slightly acid to neutral litmus paper; at the end of third month the color had faded to one-fourth that of the checks and the reaction to litmus paper was faintly alkaline.

Other synthetic media.—The following additional media were tried:

(*a*) Water 400 cc., dipotassium phosphate 80 mg., ammonium phosphate 40 mg., magnesium sulphate 40 mg., sodium acetate 2 g.

(*b*) Same as (*a*) omitting the sodium acetate.

(*c*) Same as (*a*) substituting sodium formate for sodium acetate.

No growth occurred in (*b*) or (*c*). In (*a*) the characters of growth resembled those in Dunham's solution, but about twice as much deposit was formed. Reaction of sterile medium slightly acid to litmus paper, that of culture slightly alkaline after the sixth day.

Cooked vegetables.—Tubes of various vegetables were prepared by placing in each tube a cylindrical piece of the vegetable cut a little smaller than the tube and about 5 cm. long, the upper half of this piece being slanted to receive the inoculation and the lower half immersed in distilled water. These were cooked and sterilized by steaming on each of three successive days.

Carrot cylinders prepared in this way formed an excellent medium, the chief cultural features were as follows : At 22°–25° C. the liquid was well clouded in 24 hours, and a slight white growth was usually visible on portions of the slant surface ; on the second day the clouding so increased as to render the liquid nearly opaque, and there was evidence of slight evolution of gas ; growth usually covered much of the surface of the cylinder, smooth, moist, white, thin and not fully hiding the color of the substratum. In older cultures this growth became slightly thicker, but was rarely sufficient to hide the color of the substratum or extended enough to fully cover the surface of the cylinder. Gas formation ceased after three or four days, and other evidences of vigorous growth were lacking after the first week. There was little or no tendency to form pellicle or rim. A white or cream-white precipitate began to form after two or three days, ultimately becoming rather copious. The tissues of the cylinder were rapidly softened so that at the end of a week or less they might collapse if the tube was vigorously shaken. This occurred in some cases within two days. There was little or no discoloration of cylinders. The reaction of the sterile medium is acid to litmus paper. Vigorous cultures three days old showed the liquid still slightly acid, but the tissues of the cylinder alkaline. At the end of one week the liquid also was quite strongly alkaline and more decidedly so at the end of four weeks.

Potato.—The growth characters on cooked potato cylinders were in general similar to those on carrot. The growth on the surface of the cylinder was rather more copious, forming a slightly elevated, smooth, wet-shining, cream-white layer. The precipitate was also a little more copious. There was slight evolution of gas during the first week. The clouding of the liquid was lessened after a week or ten days, but in no case did it entirely disappear. There was a tendency to form zöogloea masses and an imperfect pellicle during the first few days.

Reaction to neutral litmus paper : sterile medium acid ; on the second day the liquid was acid, but less so than when sterile, surface growth on cylinder alkaline ; third day, liquid slightly alkaline ; and this alkalinity increased so that it was decidedly alkaline at the end of four weeks.

A slight graying of the potato cylinder resulted. The cylinders were softened somewhat, but not so completely as were the carrot.

Iodine tests of potato cylinders from old culture tube showed them to be rich in amylo-dextrin, evidently produced by the action of the organism on the starch.

Other vegetables.—Similar slant cylinders in tubes of the following vegetables were used :—common red beet, sugar beet, turnip, ruta baga, radish, sweet potato, onion, asparagus, cocoanut. Good growths appeared in all except the cocoanut, where the development was slight and the tissues were not softened. The general character of growth on these vegetables was similar to that on carrot and potatoes, viz.: quick, heavy clouding of the liquid with delicate white surface growth on the moister portions of the vegetable cylinder, and slight evolution of gas during the first few days of growth.

2. BIOCHEMICAL FEATURES

TEMPERATURE RELATIONS.—*Growth at medium and high temperatures.*—The organism grew well at the usual laboratory temperatures of 20°–25° C., but better at the higher of these. It made a good growth in the thermostat at 33°–34° C., but grew less rapidly at this temperature than at 20°–24° C. The optimum lies between these two and is probably about 27°–30° C., but was not more accurately determined.

There was a slow growth on agar slants and in nutrient broth held at 35°–36.5° C. for six days, but no perceptible growth under these conditions on tubes of steamed potato or of turnip.

There was a very slight clouding of broth tubes held 24 hours in the thermostat at 38°–39° C., but much less than in similar tubes held at 24°C. for the same time. The temperature was then raised above 39°C., and was held for twenty days between 39°–40.5° C. The cloudiness which had appeared in these broth tubes during the 24 hours at the lower temperature, disappeared and the liquid thereafter remained entirely clear, indicating that there was no further growth. At the end of thirteen days, several of the tubes were removed from the thermostat and held at 22°–25° C., but there was no growth. At the end of twenty days the remainder of the tubes were removed to room temperature and held for some time, but no growth was made.

It appears, therefore, that the maximum temperature of growth lies at, or slightly below, 39° C., and that a continued exposure to a temperature slightly above 39° C., is fatal to the organism.

Growth at low temperatures.—The organism made no appreciable growth when held for twenty days at 0.6° to 1° C. upon various media (nutrient broth, Uschinsky's solution, gelatin, potato). In tubes so held, however, growth was prompt when they were removed to temperatures of 20°–24°C., indicating that there is no appreciable injury from such refrigeration.

At 2° C., gelatin tubes showed very slight growth within twenty-four hours, but there was none at the end of four days on various other media tried (broth, agar, steamed potato and turnip).

At 3° C., there was a better growth in gelatin than at 2°, with appreciable liquefaction, and slight growth developed on agar, but none at the end of five days in various other media tried (broth, steamed potato and turnip).

At 4° C., there was perceptible clouding of broth at the end of twenty-four hours, and this slowly increased, but there was no appreciable growth at the end of seven days on any of the following steamed vegetables: potato, carrot, turnip, ruta baga.

At 12° C., there was a slow growth on the above mentioned steamed vegetables, estimated on the fifth day as equalling one-third of the amount made on similar tubes held at 20°–24° C.

Thermal death point.—In these determinations, use was made in all cases of thin tubes of approximately uniform size, 15 × 1.5 cm., and each containing 10 cc. of nutrient broth, reaction +1.7 per cent. The method followed was to transfer to each tube a 1 mm. loop from broth cultures one to six days old. These were allowed to stand for from one-half hour to two hours before heating. The heating was done by immersing such recently inoculated tubes for three-fourths their height in a large kettle of water which was kept constantly stirred by an agitator in the bottom. The temperature was recorded at intervals of thirty seconds throughout the period of immersion and in most cases the extremes of variation during the period of immersion covered less than one tenth of one degree. Under such conditions the thermal death point of the organism was found to be 51° C., in most cases slightly under this. Temperatures as low as 47° had a perceptible retarding effect, however, and all above 49° retarded growth decidedly.

In Uschinsky's solution the thermal death point was found by the above method to be fully one degree higher than in the broth. Uschinsky's solution is slightly acid to litmus paper, whereas the broth was neutral or very slightly alkaline (+1.7 percent), and it is probable that this difference may explain the difference in thermal death point.

Relation to free oxygen.—Cultures in fermentation tubes in both nutrient broth and Uschinsky's solution, show the organism to be a faculative anaerobe. (See later discussion.) This fact is also shown by its growth in gelatin and agar stabs along the full length of the puncture, although in both it makes a better growth near the surface.

Growth in partial vacuum.—Broth tubes recently steamed and inoculated were placed in a sealed chamber from which the air was so exhausted as to sustain a mercury column of but 9 cm. ($3\frac{1}{2}$ inches) in height. Growth was much retarded but not wholly checked. At the end of eleven days it

was estimated to be one-half as much as in control cultures of the same age which had stood in the normal atmosphere.

Growth in oxygen-free atmosphere.—The organism made a feeble growth in oxygen-free atmosphere as was shown in the following trials. Recently steamed and freshly inoculated tubes of broth and agar were placed in small chambers from which the oxygen was removed by the Buchner method (pyrogallic acid and potassium hydroxide). There was appeciable clouding of the broth at the end of 24 hours, though much less than in normal atmosphere. This cloudiness increased but slightly during five days during which it was under observation. Feeble growth was visible in the agar on the third day and increased slightly during the remaining two days of the experiment.

Growth was estimated at end of five days to be less than one percent of that in normal air.

Growth in hydrogen.—Pure zinc (free from arsenic) and c. p. sulphuric acid were used in the generator, the gas was washed through solutions of silver nitrate and of potassium permanganate and distilled water. Displacement was secured by passing a continuous stream of the gas through the culture chamber (jar) for one hour. The chamber was then hermetically sealed and stood unopened for 13 days.

Upon opening,there was evidence of very slight growth in the nutrient broth, milk (coagulated), agar slant, five percent glycerine agar, five percent cane sugar agar (scarcely perceptible).

There was no perceptible growth in tubes of cooked carrot or cooked potato.

Upon holding in atmosphere at room temperature growth appeared or continued in plain agar, gelatin, nutrient broth, milk, cooked potato; there was no evidence of growth in the others following their removal from the hydrogen.

Growth in carbon-dioxide.—A feeble growth occurred in an atmosphere of carbon-dioxide upon the following media: broth, Dunham's solution, milk, agar, and agars containing five per cent of either cane-sugar, mannit, or glycerine. The organism refused to grow and ultimately perished when confined in carbon-dioxide upon the following media: Five percent grape-sugar agar, Uschinsky's solution, gelatin, sodium acetate medium (see page 320) cooked carrot and cooked potato. These conclusions are based upon three trials of which the detailed records are as follows: c. p. hydrochloric acid was used in the generator and the gas was passed through wash bottles of each one percent caustic potash and distilled water before entering the chamber. In series one and two the displacement of the air by the carbon dioxide was secured by successively exhausting the gas from the chamber (to three inches of mercury) and refilling with carbon dioxide. This was repeated for five successive times, with an interval of from 10 to 30

minutes between each to allow of complete diffusion. In series three the displacement was accomplished by passing a rapid and continuous stream of the gas through the chamber for one hour. The chambers were then allowed to remain hermetically sealed for from 10 to 17 days. In all cases when opened the gas within refused to support combustion.

In series two, two tubes containing methylene-blue (Dunham's sol. + 1 per cent grape sugar + methylene blue) were included as a test of the presence of free oxygen. These tubes were slowly bleached during the first week to a nearly colorless condition and remained so until the chamber was opened. Upon exposure to the air for a few minutes the surface layers resumed their original deep blue color, thus showing clearly the absence of free oxygen in the sealed jar.

After removal of the tubes from the gas chamber they were held for some weeks in the normal atmosphere at laboratory temperatures, 23°–32°C, to determine the viability of the organism.

The results from each of the three series are shown in the following table. The number of tubes of each medium is indicated by the figure in parenthesis.

GROWTH IN CARBON DIOXIDE

	Series 1, in CO_2 10 days		Series 2, in CO_2 13 days, temperature 28°-32° C.		Series 3, in CO_2 17 days, temperature 25°-32° C.	
Medium	Growth in gas chamber	Growth after removal	Growth in gas chamber	Growth after removal	Growth in gas chamber	Growth after removal
Gelatin	....	....	(2) none	none	none	none
Agar	....	....	(1) feeble	continued	(1) trifling	continued
5 percent cane-sugar agar	....	....	(1) feeble	none (?)	(1) very feeble	continued
5 percent grape-sugar agar	....	....	(1) none	none	....	....
5 percent mannit agar	....	....	(1) feeble	feeble (?)	....	....
5 percent glycerine agar	....	....	(1) feebler than man'it	continued	(1) very feeble	doubtful
Nutrient broth	(2) feeble	continued	(2) feeble	continued	(1) very feeble (?)	continued
Milk	....	....	(2) feeble *	continued	(1) growth coagulat'n)	....
Uschinsky's solution	(2) none	none	(2) none	none	....	....
Sodium acetate medium †	....	....	(2) none	none	....	....
Cooked carrot	....	....	....	....	(2) none	none
Cooked potato	....	....	....	....	(1) none	none
Methylene blue ‡ peptone solution	....	....	(2) feeble	doubtful gr.	....	....

* This milk showed no coagulation upon removal from the CO_2 chamber, but upon immersing in boiling water it coagulated immediately, showing that there had been growth.

† See p. 320

‡ Dunham's solution plus methylene-blue plus 1 percent grape-sugar, see p. 319. This was inserted partly to serve as a test of the oxygen content of the jar.

Reduction of nitrates to nitrites.—The following medium was used to grow the organism on in order to determine its action on nitrates:

Distilled water	1000 cc.	
Witte's peptone	10 grams.	
Cudahy's beef extract	2½	"
Potassium nitrate, (c. p.)	3	"

Sodium hydrate to make the reaction + 1.0 percent.

The medium was tested by the starch-iodine method showing the absence of nitrites before it was used. Tests of cultures in this nitrate broth on the fourth day after inoculation showed the presence of an abundance of nitrite, other tests on each the fifth day, the sixteenth day and the twentieth days, gave the same results.

Indol production.—This occurs under favorable circumstances. Two cultures in Dunham's solution (10 cc. each tube) 20 days old and one 22 days old were tested by adding to each 15 drops of a mixture of 2 parts c. p. sulphuric acid in 1 part distilled water. After waiting a few minutes to be sure of the absence of nitrites, added 1 cc. of 1 per cent sodium nitrite solution. No coloration appeared at first, but within five minutes a slowly deepening pink color showed the presence of indol. This color was not so deep as was obtained in the same medium by a culture of *B. coli-communis* which was tested at the same time. The coli culture, was, however, from a strain known to give a very pronounced indol reaction. Similar tests made several times since have given similar results. A second series of tests was made using cultures in moderately alkaline peptonized beef broth, rendered sugar-free by the previous growth in it of *B. coli-communis* for 15 hours. Cultures 22 days old were tested in the manner described above. No color was apparent upon adding the acid, nor did any appear upon the addition of the nitrite. After waiting five minutes the tubes were heated in the water bath at 75-80° C. After a few minutes warming the characteristic color reaction of indol appeared and deepened into a bright pink. This color persisted upon cooling. The depth of the color was estimated at one-seventh of that obtained with the cultures of *B. coli-communis* of the same age.

Development of odor.—There was little odor from cultures upon most media. The only cases where it was sufficiently developed for characterization were in milk cultures (p. 318) which gave a cheesy or curd-like odor; in cruciferous roots (p. 309), both uncooked and cooked, where there was an offensive odor suggesting mercapan; and in onion (p. 310) where the odor was also decidedly offensive.

Production of hydrogen sulphide.—Strips of absorbent paper saturated with a solution of lead acetate were suspended in tubes containing young cultures upon the following media: cooked cylinders of cocoanut, carrot, potato and turnip, Uschinsky's and Dunham's solutions and nutrient broth. These remained for over a week, being several times remoistened. There

was slight blackening of the papers, showing evolution of hydrogen sulphide, in some of the potato tubes and in the turnip tubes, and a more pronounced blackening in the broth tubes. Some potato cultures did not blacken the papers, however, and no blackening occurred from the remainder of the media.

Production of acids.—The detailed statements already made of the reactions of cultures upon various media justify the following conclusions:

In the presence of various carbohydrates there is active acid formation usually accompanied by a small amount of gas production. Litmus milk cultures (p. 318) were promptly reddened. In such acid milk cultures the acid was in part volatile and in part non-volatile. The kind of acid was not determined in any case except that in fermentation tubes, twenty percent of the gas formed was carbonic acid.

Numerous comparisons of two percent cane, grape and milk sugar and glycerine in broths showed greatest acid production from the grape-sugar, abuot the same amount from milk and cane and much less from glycerine. The exact data is given later under the discussion of fermentation tube cultures. When there was a considerable amount of the sugar in the medium, the acid production was so great as to destroy the organism. Thus, in Dunham's peptone solution plus one percent of grape-sugar, there was rapid growth, the medium became decidedly acid and death of the cultures resulted within nine days. In Uschinsky's solution, having five percent of cane-sugar, the tube became sterile after forming only one-half as much deposit as was developed in the unmodified solution. The growth must have continued in this case for several weeks, but the exact time of death was not determined. In fermentation tube cultures in two per cent sugar broths, very few living organisms remained in the liquid in the bowl of grape, cane or milk-sugar tubes upon the fifteenth day. Conceiving that this acidity might interfere with the activity of gas production in the fermentation tubes, a series of cultures was made in tubes (including two per cent grape, cane, and milk-sugars, and mannit) where about one gram of calcium carbonate was inserted in each tube. The result was, however, the partial inhibition of growth in the presence of the marble and the production of only about ten percent as much gas. These cultures became acid but less so than similar ones lacking the calcium carbonate.

Alkali production.—This apparently was a constant accompaniment of growth, but in no case was it great. Thus, broth cultures, one month's growth at laboratory temperature, in which the original medium had a reaction of +1.5 per cent to phenolpthalein, gave a reaction of —1.0 per cent. In all cultures where there was continued growth following the exhaustion of carbohydrates or other materials favorable to acid development, the alkalinity slowly increased with age. Examples of this have already been cited under the various culture media. See especially the discussion of rosolic-

acid-peptone cultures (p. 320) and of the acid-fuchsn-peptone cultures, (p. 320).

Relation of growth to acids and alkalies.—It has been stated under the discussion of acid production, that the development of the organism may be inhibited and the cultures may ultimately be destroyed by acid-production in media containing sufficient amounts of certain carbohydrates. The relation of growth to the reaction of the medium was more exactly observed, as follows: Cultures in broth which was neutral to phenolpthalein were compared with these rendered alkaline by sodium hydroxide to —2.0 percent and —4.0 percent, and also with others to which malic acid was added to make the reactions +3.0 percent, +6.0 percent, +9.0 percent and +12.0 percent. The neutral broth gave the best growth. The comparative rate of growth, as shown by the relative cloudiness of the tubes upon the second day, 28°–30° C., was estimated as follows: neutral broth=100 per cent; — 2.0 broth=80 percent; —4.0 broth=50 percent; +3.0 broth=10 per cent. There was no growth in broths +6.0, +9.0 or +12.0. Agar tubes were prepared having reactions of —8.0 percent, +6.0 percent, +9.0 percent and +12.0 percent. Slant tubes of these were heavily inoculated and held for four days at 25°–30° C. There was doubtful growth in the alkaline tube, none on any of the acid tubes. These results are noteworthy in comparison with the power of the bacillus to grow and induce decay in green tomatoes, of which the juice shows a reaction to phenolpthalein of +4.0 to +5.0 percent,[1] or even greater acidity according to Dr. Smith's titrations.

Relation to light.—The bacillus is very sensitive to sunlight. Freshly poured agar plates, one-half shaded by closely covering with opaque brown card, were exposed to sunlight at mid-day, early in September. Exposure of ten minutes killed every organism; five minutes exposure killed 87 per cent; three minutes killed 70 percent; one minute killed 33 percent; ten seconds killed 7 per cent. Moreover there was appreciable retardation in the development of those colonies which did appear in the plates receiving even the ten seconds exposure. Longer exposure to diffused light is also fatal. Thus in plates where one-half was covered, above and below and at the circumference, with opaque brown card, exposure for one hour destroyed all organisms for 7 mm. back from the line of exposure, and exposure for one and one-half hours led to nearly or quite complete sterility in the shaded portions of similar plates, diameter 8 cm. The organisms were in all of these cases from twenty-four hour broth cultures. The temperature within the plates during their exposure was 35° C.

Desiccation.—This bacillus has proved remarkably sensitive to desiccation, drying for even a brief period in the atmosphere at laboratory tem-

1 The acidity of the juice of each of several of the different kinds of vegetables used in inoculation experiments was determined by titration with phenolpthalein. Green tomatoes one-half to two-thirds grown, showed an acidity ranging from +4.0 to +5.0 percent; potatoes were +3.0 to +4.0 percent; carrot roots were +2.8 to +3.6 percent. The baccilus was actively parasitic in all of these.

peratures proving fatal. Thus in one series of experiments a 1 mm. oese was transferred from a broth culture twenty-four hours old to each of several sterile cover glasses. These glasses were then dropped into sterile broth tubes after drying for varying periods of time, temperature 28°–31° C. Exposure for twenty minutes or less, after the last trace of visible moisture left the glass, (thirty minutes after the transference of the loop from the tube,) rendered most of the covers sterile. In a few cases living organisms remained on covers thus dried for several hours, but this was probably due to the formation of a surface film which prevented the desiccation of some of the buried organisms. The experiment was repeated, diluting the broth with sterile water. When drops of this diluted culture were subjected to desiccation, temperature 22° C., some of the covers were found to be sterile after but two minutes drying.

Behavior in fermentation tubes.—Several series of fermentation tube cultures were made in which sugar-free nutrient broth [1] was the foundation medium. Trial was made of 2 percent additions to this of each grape, cane and milk sugar, mannit and glycerine. Temperature 20°–24° C. In all trials sugar-free tubes were held as checks.

The more important results are summarized in the following table :

TABULAR SUMMARY OF RESULTS IN FERMENTATION TUBES*

Medium Broth with 2% of	Volume of gas in percent of closed branch				Reaction of broth in bulb, 15th day(†)	Composition of gas	
	2 days	3 days	5 days	15 days		Carbon dioxide	Explosive
Grape-sugar	small bubble	3%	4%	5%	+6.4%	20%	80%
Cane-sugar	" "	4%	6%	10%	+6.0%	20%	80%
Milk sugar	o	1%	5%	15%	+5.8%	20%	80%
Mannit	small bubble	4%	6%	8%	acid to litmus	20%	80%
Glycerine	o	o	o	o	+3.0%	20%	80%
Sugar-free broth	o	o	o	o	+1.6%	20%	80%

* *B. coli-communis* was carried through in a duplicate set of fermentation tubes in one of the above series for purposes of comparison. No gas was formed in the cane-sugar tubes and they remained alkaline. In the milk and grape-sugar tubes gas formation began earlier than with the carrot rot and continued more vigorously, so that at seventy-two hours it occupied 25 to 30 percent of the closed end of these tubes. This gas evolution continued but slowly thereafter, amounting on the fifteenth day to 38 percent in the milk-sugar, and 30 percent in the grape-sugar tubes. Titration showed the acidity of the liquid in the bowl to be +5.2 percent in milk-sugar and +5.6 in grape-sugar. The gas composition was about 30 percent soluble in KOH, remainder explosive.

† In one series the liquids in the closed branch were titrated also. The reactions were practically the same as in the corresponding bowls, except in the sugar-free tubes. Three of these were tested and the results, which were very similar in the three, showed an average acidity of +2.6 percent in the closed branch as compared with +1.6 percent in the bowl.

1 Broth made from beef, Witte's peptone, reaction +1.5 percent, freed from muscle-sugar by growth in it of *B. coli-communis* for twelve hours, as recommended by Dr. Theobald Smith, Jour. Exp. Med. II, p 556. Pains were taken to secure pure sugars.

In the bulbs.—There was prompt uniform clouding in all except the milk-sugar, where no growth was apparent until the second day. In sugar-free broth the cloudiness was not heavy, and it persisted during the trial (15 days); the glycerine bulb was most densely clouded of any, persistent; in the grape and cane-sugars, the clouding was less dense than in glycerine, and began to clear after the third day; in milk-sugar the clouding was slower than in cane and grape, both in developing and also in beginning to clear. In these three sugars the bowls were clear, or practically so, before the end of the period. No pellicle was formed in any case, and no color developed.

Transfers from the bulbs were made in one series to determine whether the organisms had survived the acidity. There was prompt growth from the sugar-free and glycerine bulbs, slower growth from milk and cane-sugars, and none whatever from the grape-sugar. In another series the results were similar, except from the grape-sugar, where growth resulted, but very tardily indicating that most of the organisms were dead.

In the connecting tube.—No distinct deposit formed in the sugar-free or glycerine tubes. In the others there was a distinct granular deposit which was 2 mm. deep in the milk-sugar tube, and slightly less in the other sugars. The amount of the deposit corresponded in a general way to the amount of gas evolved. The heavier clouding of the bowl extended in all cases to the inner curve of the connecting tube, where it merged into the fainter clouding of the closed branch in the earlier stages of growth. As the growth and gas formation in the closed end began to decline, a sharp line of delimitation was developed at this inner curvature.

In the closed branch.—Faint uniform clouding appeared on the second day in all, although more tardy in milk-sugar and in glycerine than in others. This cleared away after about three days in the sugar-free and the glycerine tubes. The sugar tubes began to clear at the upper end on about the fifth day, but none of them became fully clear during the fifteen days.

Gas formation.—As shown in the table above, this began in grape and cane sugars and mannit on the second day, but was one day tardier in milk sugar. The evolution of gas continued pretty actively in the milk-sugar until about the tenth day, but in the other sugars and mannit there was little evolved after the sixth day.

V. REMEDIAL MEASURES

The studies already detailed show that this organism is capable of developing as a wound-parasite upon a wide range of hosts. Its behavior in cultures in the laboratory indicates, also, that it can live indefinitely as a saprophyte where conditions are favorable. The nature of such a rot precludes the possibility of any specific remedy. The treatment must aim entirely toward prevention. The facts presented in the preceding discus-

sion show clearly the importance of attention to (1) rotation of crops, and (2) manuring. The laboratory studies which are detailed in the following pages, indicate the like importance of (3) thorough drying of the surface of roots, of (4) their exposure to the sunlight before storage and of (5) constant low temperature during storage. By attention to these preventive measures it is probable that the rot can be avoided or practically held in check.

Rotation of crops.—The practical importance of this in the case of serious trouble with any such rot as the one under discussion, is so patent as to require little emphasis. The fact that this organism is capable of attacking such a variety of vegetables, makes such measures peculiarly necessary. Infested soil should be devoted for a period of years to such crops as corn, other grains and grasses. If desired for garden use, the bush fruits could probably be grown safely, or seed crops, such as peas, beans, etc. Among the root-crops beets or possibly potatoes would not be objectionable.

Manuring.—The danger of introducing and perpetuating various injurious germs with compost and manure, is greater than is generally supposed. For example, it has been shown that club-root of cabbage is often brought in with the manure,[1] the same is true of corn smut, and apparently so to a greater or less degree of a considerable number of the fungus and bacterial diseases of garden and field crops. The careful cultivator, therefore, should always aim to guard against this danger. Mr. Chandler's experience, cited on page 303, indicates that the manure pile may be a serious source of soil contamination with this carrot-rot germ. While this is not demonstrated, the evidence is sufficient to show the wisdom of applying manure or compost of doubtful character to crops that are not susceptible to these soft rots, and on the other hand, to use alone for such susceptible vegetables, manure from grain and hay-fed animals, or compost into which garden refuse has not entered.

3. *Drying of root surfaces.*—One of the most striking characters of this organism is its susceptibility to desiccation, as shown by the experiments cited on page 303. Drying under ordinary conditions of the summer atmosphere was almost immediately fatal to the organism. Since the germs must be conveyed to the storage cellar almost exclusively on the surface of the roots, it follows that if these surfaces can be thoroughly air dried before their storage, practically all of the rot-germs will be killed. To secure this they should be left lying on the surface of the ground in the field for some days after pulling, and stored in as dry a place as possible. The efficacy of such treatment is increased by the fact that the organism cannot invade dry tissues. The prompt drying out of the surface wounds which are made in harvesting and trimming the crop will contribute largely

1 See discussion Vt. Exp. Sta. Bul. 66, p. 7 (1898).

to their disinfection. As shown in the following paragraph, this treatmer will be made still more effective if the drying is accompanied by exposur to sunlight.

4. *Exposure to sunlight.*—Laboratory experiments along this line ar reported on page 328. These show that exposure of the organism for te minutes to direct sunlight, and for two hours to diffused light was fatal This fact, coupled with its extreme sensitiveness to desiccation, indicat that the best practical means of disinfecting the surfaces of suspected root is to thoroughly expose them to dry air and sunlight.

5. *Temperature in storage.*—The practical importance of cool storage i recognized by everyone. The growth of this organism decreases from a optimum temperature of about 77°-83° F. (25°-28° C.) to the zero point. Growth is quite slow, however, below 50° F. (10° C.) and is practically checked below 39° F. (4° C.). These temperatures are practicable for any good storage cellar, and coupled with the disinfection of the root-surfaces by drying and sunlight, should prevent serious danger from the rot.

REPORT OF THE BOTANISTS

L. R. Jones and A. W. Edson

There has been no essential change in the aims or nature of the work of this department during the year. It seems best to print annually the results secured in certain lines of work. The publication of other matter is delayed until the accumulated observations and experiments of a longer period permit more exhaustive treatment. Some of the most important work of the past twelve months will not be ready for publication until another year at the earliest, and on the other hand, some of the discussions of the present report are based on work done several years ago:

The subjects reported upon are as follows:

POTATO DISEASES AND THEIR REMEDIES

I. POTATO BLIGHTS AS THEY OCCURED IN 1900

The season of 1900 was somewhat peculiar. The continued dry weather of the midsummer was not favorable to the development of potato tubers, but, on the other hand, prevented any extensive loss from fungus diseases. There was no late blight or dry rot in the experiment station fields,

although there was considerable loss from dry rot on adjoining farms. We attribute our freedom from the disease in part to clean seed, and in part to spraying. There was a considerable amount of early blight (*Alternaria Solani*) in many fields during the middle of September. The rains of that month made conditions more favorable for the growth of such potatoes as had survived until that time. Owing to lack of moisture, tip burn appeared much earlier than in the previous season, and was very much in evidence from midsummer on. Many fields were almost entirely dead from this cause by September first, especially those planted on sandy soil or in hilly portions of the state. The Colorado potato beetles were more troublesome in 1900 than in 1899. The flea beetles, as usual, were quite destructive, and the tip burn frequently started from their injuries. Spraying with bordeaux mixture enabled the plants to survive the unfavorable conditions of the summer months and to make use of the more favorable weather of September.

II. RESULTS FROM SPRAYING POTATOES IN 1900

1. PLAN OF THE EXPERIMENTS

Experiments were planned, much like those of former years, to determine the relative values of several fungicides and of their use at different dates. The following compounds were tested:

Standard bordeaux-paris-green mixture.—One and one-half pounds of copper sulphate, 1 pound of lime, 2 ounces of paris green, 10 gallons of water. The method of preparing the mixture was the same as that used in former years.[1]

Boxal.—A commercial insecticide and fungicide combined, manufatured by the Bowker fertilizer company.

Bodo.—A concentrated commercial fungicide designed to take the place of bordeaux mixture, manufactured by the Bowker fertilizer company.

The potatoes were planted May 23d on a fairly uniform, sandy-loam soil which had been in grass for some years previous. Early in the summer all plants were sprayed with paris green in water; and later the control rows were paris-greened at the same time that the several applications were made to the experimental rows. These experimental applications were made July 2, July 16, August 4, and August 23.

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1 Vt. Sta. Rpt. 13, p. 269 (1900).

The rows were sprayed as follows:

Rows 1 and 2.	Bordeaux mixture ; 4th spraying only.
Rows 3 and 4.	Boxal ; four applications.
Rows 5 and 6.	Controls ; paris green.
Rows 7 and 8.	Bordeaux mixture ; 3d and 4th syrayings.
Rows 9 and 10.	Bordeaux mixture ; 3d and 4th sprayings.
Rows 11 and 12.	Bordeaux mixture ; 3d spraying only.
Rows 13 and 14.	Bodo ; four applications.
Rows 15 and 16.	Controls ; paris green.
Row 17.	Non-experimental, paris green.
Rows 18 and 19.	Bordeaux mixture ; 1st and 2d sprayings.
Rows 20 and 21.	Bordeaux mixture ; 1st, 2d, and 3d sprayings.
Rows 22 and 23.	Bordeaux mixture ; 1st, 2d, 3d and 4th sprayings.
Rows 24 and 25.	Bordeaux mixture ; 1st, 2d, 3d and 4th sprayings.

2. RESULTS FROM THE USE OF THE DIFFERENT COMPOUNDS

Observations were made from time to time upon the condition of the plants receiving the different treatments. The potatoes were dug October 15 and the yields noted. During July and the first part of August no difference could be distinguished in the plants, but by August 9 differences began to be manifest and thereafter increased.

Bordeaux-paris-green mixture.—After August 9 the rows sprayed with this preparation were plainly distinguishable from the control rows, and to some extent from those upon which other preparations were used. The plants were large and flourishing and continually sending out new shoots. The leaves were large, of a rich dark green color, and not troubled by flea beetles. Even when dug the stems of these plants were green and there were some green leaves still left on the vines.

The yields from the rows sprayed twice at the most favorable dates with bordeaux mixture were at the rate of 285 bushels to the acre. This was about 60 bushels more than were dug from the control rows, and also more than was given in the rows sprayed by the other compounds. The superiority of bordeaux mixture is thus again shown.

Control rows.—These were simply sprayed with paris green in water. They were inferior to the bordeaux rows on August 9, and from that time on gradually declined and withered away. Practically all the plants were dead when dug. These plants suffered much more from the flea beetles and tip burn than did the others in the field. The yield was 224¼ bushels an acre, which is less than any of the other treatments gave.

Bodo.—These rows compared favorably in general appearance with those treated with the standard bordeaux mixture. The plants were kept green and thrifty and comparatively free from flea beetles and tip burn. The preparation is convenient to use and does not clog the spray nozzles. The yield was 232½ bushels an acre. It is not quite fair to compare this yield with that of bordeaux, since soil conditions were better where the bordeaux rows were planted. The general appearance of the plants would indicate that *Bodo* is more nearly equal to bordeaux than is shown by these figures.

Boxol.—This is primarily an insecticide. Unfortunately it was not used early enough in the season to compare its merits with those of paris green for killing Colorado beetles. While not the equal of *Bodo* it is very useful in keeping off the flea beetles. It is not as effective in keeping plants in a thriving condition, but the indications are that it has much value in controlling insects.

3. RELATIVE VALUES OF THE APPLICATIONS AT DIFFERENT DATES

As stated above sprayings were made July 2, July 16, August 4, and August 23. On each of these dates the spraying was omitted from some of the rows in such a way as to compare the value of the applications made at the several dates. No differences appeared in these rows until after the third spraying. Soon after that those plants which had not received the application of August 4 were so badly affected by tip burn that whole stems died. This occurred about as often on these rows, (which had received applications 1 and 2, but not application 3) as on the control rows. The yields as given below are in harmony with the conclusions reached from the appearance of the foliage, namely, that there was no important gain from the first and second sprayings. Moreover, as shown by the appearance of the foliage, those that received only the third spraying were very nearly as thrifty as those that had been given the first three applications. The fourth spraying did not make much difference in the appearance of the foliage. Those that had received only the first and second kept on dying; those that had received the third continued to thrive whether they had received the fourth application or not. The appearance of foliage alone indicated that the chief benefits were derived from the third spraying. The yields of tubers, however, showed that the fourth application had considerable effect.

The greatest gain in 1899 came from a spraying made July 26. This difference in date simply serves to emphasize the general truth that in deciding when to begin spraying, as when to begin haying or harvesting, one should use judgment which is only to be gained by experience.

1 Vt. Sta. Rpt. 13, p. 273 (1900)

YIELDS FROM POTATO PLOTS SPRAYED AT DIFFERENT DATES

Date of spraying	Yield to the acre
Controls—paris green alone,	225
Bordeaux mixture, July 2, July 17,	227
" " " " " " Aug. 4,	240
" " " " " " " " Aug. 23,	236
" " Aug. 4,	234
" " " " Aug. 23,	285
" " Aug. 23,	267

III. POTATO SCAB EXPERIMENTS OF 1901

Experiments have been made in preceding years with various methods of disinfecting scabby seed potatoes. The conclusions to date were summarized in our last report. Similar trials were made in 1901[1], and the early harvesting of the crop permits the insertion of the results at the present time.

PLAN OF THE EXPERIMENT

Seed.—Three lots of seed potatoes were selected, as follows:

(1) Rural New Yorker. Each potato had from one to several well developed scab spots. Used in rows 1-16.

(2) Delaware. About as scabby as the Rural New Yorker seed. Used in rows 32-55.

(3) Delaware. Every tuber was exceedingly scabby. Used in rows 18-29.

Disinfection.—Each of the above mentioned lots of seed potatoes was divided into six portions. One portion of each was put aside for planting in the control rows without attempt at disinfection. Each of the remaining portions was subjected within from one to three days before planting to one or another of the following methods of treatment aiming at disinfection.

1. Corrosive sublimate.—One ounce in eight gallons water; seed potatoes soaked one and one-half hours in the solution.

2. Formalin.—One-half pound in fifteen gallons water; seed potatoes soaked two hours in the solution.

3 Formaldehyde gas[1].—The potato tubers were placed in shallow wooden boxes in layers about six inches deep. These boxes were then set upon barrels in a small room, 10 x 12 x 8½ feet, giving a total content of 1020 cubic feet. The walls on two sides were of stone, on the others of closely matched wood. The floor was of cement. The one window and one door were tightly closed, and cracks and keyholes stopped with cloth.

1 Vt. Sta. Rpt. 13, pp. 273-281 (1900)

The Schering formalin lamp with accompanying pastils was used for generating the gas, as described in the last report[1]. Sixteen of the 1-gram pastils were evaporated, this number corresponding to the directions given in the circular accompanying the lamp for the destruction of pathogenic bacteria. The room remained closed for twenty-four hours.

4. Formalin vapor.—The room described above was used, and the seed potatoes were placed in similar receptacles. The vapor was generated by placing one-half pint of formalin in a common dinner plate, supported about ten inches above the floor of the room. Close beside it was placed a small kerosene stove on which a kettle of water was so placed that the water stood about on a level with the formalin. The water was kept boiling during the twenty-four hours of the fumigation.

5. Sulphur fumes.—The same room was used and the potatoes distributed in the same way as in methods 3 and 4 above. A hod full of glowing coals were taken from a furnace, and upon these was laid an iron shovel containing 10 grams of flowers of sulphur. The door was immediately closed and so left for thirty-six hours.

In addition to these five methods of seed treatment previous to planting, two methods of soil treatment were tried on certain rows, as follows:

Sulphur.—Flowers of sulphur was used at the rate of 300 pounds to the acre. The seed was rolled in the sulphur, and the balance was scattered in the open drill immediately after dropping the seed pieces.

Bran.—At the request of several potato growers wheat bran was scattered in the drill after dropping the seed, at the rate of forty bushels to the acre. It was stated that in certain trials the bran so used had served to prevent the scab, and at the same time was a good fertilizer.

Soil and culture.—The soil was a very light sandy loam adjoining that used in 1900 and selected for this experiment because it had recently been cleared of pine and had not since been used for other crops. It was supposed, therefore, to be free from the germs of the scab fungus. When we came to break it up, however, it was found that one corner was sodded over and had no stumps in it. Bricks, mortar, broken dishes, etc., scattered through this portion of the soil gave abundant evidence of former cultivation, presumably as a garden spot. Such use of it must have been made a great many years ago, presumably twenty-five or more years, although we were unable to learn definitely. Believing that the germs would have died out in such an interval of time, if they had ever been introduced, we included this area in the plot. When the potatoes were dug, however, we were astonished to find convincing evidence of soil contamination in this part of the field. Rows 1-8 lay for part of their

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1 See account of previous trial of this gas, with picture of lamp, in Vt. Sta. Rpt. 13, p. 275. (1900)

length in this area, and there was an amount of scab in rows disinfected with formalin (rows 4 and 5) which was far in excess of that in other portions of the field where formalin solution was used. The distribution of the scab in the rows showed beyond doubt that this was due to soil contamination. The evidence indicates, therefore, that the scab germs had persisted in this soil for many years. The only other explanation is that some invader had more recently cultivated a crop of potatoes on this soil without the knowledge of the college authorities. This does not seem probable, but the isolated location of the area makes it a possibility.

The planting was in drills, with phosphate as the only fertilizer, and flat culture was practiced. It will be observed that "non-experimental rows" were frequently interspersed to check cross contamination between rows. The entire field was sprayed three times with bordeaux-paris-green mixture. The potatoes were planted the last of April and harvested the middle of September.

Results.—When dug the tubers in each row were carefully counted and sorted into smooth and scabby. Most of the latter were not badly affected, and it did not seem profitable to go further with the sorting into different degrees of scabbiness. The results in detail are given in the following table.

As already stated the seed used for rows 1-16 was Rural New Yorker, each tuber showing from one to several scab spots.

For rows 18-29 the seed was Delaware potatoes, of which each tuber was very scabby.

For rows 31-55 the seed was Delaware, about as scabby as the Rural New Yorker.

The non-experimental rows were planted with seed which had been disinfected with formalin solution, and these were designed to check cross-contamination between rows.

TABULAR SUMMARY OF RESULTS

No. of row	Nature of treatment	Smooth tubers	Scabby tubers	Averages of two rows		
				Smooth	Scabby	Percent of scabby tubers
1	Non-experimental	—	—	—	—	—
2	Corrosive sublimate	556	24	1113	33	2.75
3	Corrosive sublimate	557	9			
4	Formalin solution	479	40	824	99	10.66
5	Formalin solution	345	59			
6	Formalin gas	446	68	825	148	15.
7	Formalin gas	379	80			
8	Non-experimental	—	—	—	—	—
9	Formalin vapor	272	127	528	233	30.50
10	Formalin vapor	256	106			
11	Non-experimental	—	—	—	—	—
12	Sulphur gas	280	56	634	128	16.75
13	Sulphur gas	254	72			
14	Non-experimental	—	—	—	—	—
15	Control	322	99	593	179	23.
16	Control	271	80			
17	Non-experimental	—	—	—	—	—
18	Corrosive sublimate	310	22	660	35	5
19	Corrosive sublimate	350	13			
20	Formalin solution	582	18	1173	48	4.0
21	Formalin solution	591	30			
22	Formalin gas	548	102	1056	208	16.5
23	Formalin gas	508	106			
24	Non-experimental	—	—	—	—	—
25	Formalin vapor	539	135	964	259	23.
26	Formalin vapor	425	124			
27	Non-experimental	—	—	—	—	—
28	Control	427	135	964	259	23.
29	Control	349	124			
30	Non experimental	—	—	—	—	—
31	Non-experimental	—	—	—	—	—
32	Corrosive sublimate	322	8	699	27	3.75
33	Corrosive sublimate	377	19			
34	Formalin solution	348	6	737	13	1.50
35	Formalin solution	389	7			
36	Formalin gas	419	58	799	172	17.66
37	Formalin gas	380	114			
38	Non-experimental	—	—	—	—	—
39	Formalin vapor	367	92	681	181	21.
40	Formalin vapor	314	89			
41	Non-experimental	—	—	—	—	—
42	Sulphur in row	482	41	916	69	7.
43	Sulphur in row	434	28			
44	Non-experimental	—	—	—	—	—
45	Control	297	60	654	144	18.
46	Control	357	84			
47	Non-experimental	—	—	—	—	—
48	Bran in row	444	120	444	120	21.
49	Control on 48	480	109	480	109	18.
50	Non-experimental	—	—	—	—	—
51	Control	487	87	937	184	16.66
52	Control	450	97			
53	Non-experimental	—	—	—	—	—
54	Sulphur gas	454	73	877	250	22.
55	Sulphur gas	423	179			

Discussion of the results.—The essential results shown by the above table may be more clearly seen in the following statement of the averages The figures in the first column are from rows 1-16 (Rural New Yorker), those in the second column from rows 18-29 (Delaware, very scabby) and in the third column from rows 32-55 (Delaware.) The fourth column shows the averages of columns I-III.

AVERAGES FROM ALL PLOTS

	I	II	III	IV
Corrosive sublimate	2.75	5.	3.75	3.8
Formalin solution	omitted*	3.66	1.5	1.8
Formalin gas	15.	16.5	17.66	16.5
Formalin vapor	30.5	23.	21.	25.
Sulphur gas	16.75		22.	19.5
Control	——	23. 29.66	18. 16.	22.
Sulphur in row	——	——	7.	7.
Bran in row	——	——	21.	21.
Bran control	——	——	18.5	18.5

*The high percentage of scab here, 10.6 per cent., was unquestionably due to soil contamination and hence these figures are omitted in the summary. See discussion of soil conditions, page 232.

It is evident from the above figures that the corrosive sublimate solution and the formalin solution were both practically successful in preventing the scab and about equal in value. For reasons stated in earlier reports we recommend the formalin as the preferable method to use and it is gratifying to note that so far as the above figures show it was slightly superior to corrosive sublimate. None of the other methods was a practical success. Flowers of sulphur in the row gave better results than last year[1]. It was distinctly inferior to the above mentioned solutions, however, and since it is far more expensive we are again lead to pronounce against it.

The results from sulphur gas and from formalin gas were both less promising than those obtained last year. We cannot recommend either for practical use in the face of our two years' experience, but we shall ourselves try them again, generating the gases in greater amounts.

Formalin vapor and wheat bran were both tried for the first time this year. They are both so evidently valueless as to deserve no further trial.

A PECULIAR ROT OF GREENING APPLES IN 1900

Many reports came to us in the autumn of 1900, soon after apples were put in storage, that the Greenings were being attacked by a peculiar rot. This trouble was common although not universal among the orchardists of the Champlain valley, and similar complaints came from elsewhere.[2] Upon each affected apple one or more small, clearly defined, brown spots appeared and gradually increased in size. When the spots reached a diameter of about one-half inch a white fungus growth appeared in the center of each, giving the apple a very peculiar and marked appearance.

This fungus was the blue mould (*Penicillium*), which is the common ripe-rot fungus of apples. It is, however, scarcely able to attack un-

1 Vt. Sta. Rpt. 13, p. 278 (1900)

2 Prof. F. C. Sears wrote that there was an unusual loss from black scab in Nova Scotia, even among those who sprayed.

injured fruit, and could not of itself cause so serious a trouble at this season of the year. Careful examination of the center of the rotting spots showed that there was in all cases a small blackened area occupied by the apple scab fungus. The blue mould started its invasion from these small scab spots. It is noteworthy that no rot developed under the larger hard, scab spots, unless they had cracked open. The scab spots from which the trouble started were very small and evidently young, since frequently they could be almost obliterated by rubbing with the moistened finger. None of these areas of decay developed on the apples while they were still in the orchard, but immediately on being placed in barrels the rot began and progressed so rapidly that frequently every apple in the barrel was affected within a few days.

There had been a severe wind storm on September 12, which blew considerable fruit from the trees in Grand Isle county. Much of this was picked up and stored in barrels. Curiously, these stored windfalls showed no signs of the trouble, neither of the small scab spots nor of the associated rot.

It is evident, therefore, that the development of these smaller scab spots—which later became the centers of the decay—occured during the latter part of September. Such a development in this climate is unusual; but so were the weather conditions of last autumn. Of the last sixteen days of September only three were clear. It rained on six days and was cloudy the other seven. Moreover this period of remarkable moisture followed one of protracted drought. These conditions were, of course, unfavorable for the healthy maturing of the fruit; whereas the moist period in September was favorable for the development of the scab fungus. There was further evidence of the weakened condition of the fruit in the early and unusually severe development of the scald in the Greenings[1]. It is interesting to note in this connection that although there were other varieties of apples, like Fameuse, in these same orchards which were attacked quite as badly by the scab, there was no accompanying trouble from the rot on any except the Greenings.

On examining the position and occurrence of these little scab spots it was found that generally they were developed upon the shaded side of the apple and that apples were more badly scabbed when they came from the interior of the tree top, or from where branches were thick and overlapping. Apples from the exterior of the trees, or from trees with spreading open tops were less affected. It was also noticed that there was more of the trouble in level orchards on low ground where the ventilation was poor, in young orchards where the branches drooped to the ground thus confining moisture, and in orchards where trees were close together and branches inter-

1 See a discussion of this in Vt. Sta. Rpt. 10, p. 55 (1896-97), and 11, p. 199 (1897-98).

woven. There was less trouble in orchards upon high land with rather sharp slopes, in orchards exposed to drying winds, and upon large old trees, especially if they were well pruned and far apart.

Matters may, therefore, be summed up as follows as to the causes of the trouble.

1. The peculiarly moist weather of the last half of September led to an unusual development of small scab spots, especially in shaded or moist situations.

2. This same weather condition following a very dry summer was unfavorable to the healthy maturity of the Greening apple and thus prepared the fruit for the early development of scald and made its invasion by fungi an easier matter.

3. The blue mould was the immediate cause of most of the decav. The invasion of this fungus could not have occured however, if the epidermis had not been ruptured by the scab fungus and the adjacent tissues weakened by the unfavorable climatic conditions.

REMEDIAL MEASURES

As indicated, much of the trouble was due to peculiar climatic conditions. These probably will not soon occur again. If they could have been foreseen a part of the trouble might have been prevented by a single late spraying with bordeaux mixture or ammoniacal copper carbonate; but one cannot as a rule foresee such things. Thorough spraying early in the season would go far toward lessening the danger of such an outbreak. Observations in numerous orchards indicate that under the best cultural conditions, where the trees were open, the trouble was considerably less serious than under less favorable conditions. Hence this experience simply emphasizes the importance of attention to general cultural conditions, and more especially to thorough pruning and regular, annual spraying. As we have before shown[1], our observations and experiments lead us to believe in the cumulative value of spraying.

FOWL MEADOW GRASS

Grass is the principal crop of Vermont. Timothy, the clovers and "June grass" or Kentucky blue grass make up the bulk of the hay and grass plants. This is as it should be. The preeminent value of these plants is beyond question for most soils of this state. But this should not obscure the fact that none of these plants is suited to all soils and conditions. There are in practically every town considerable areas of low undrained land where these grasses and clovers will not thrive and which are

1 Vt. Sta. Rpt. 11, p. 198 (1897-98).

producing an inferior grade of "swale hay". Such soil is rich, and, where it can be drained, makes the most valuable of meadows, especially adapted to a mixture of timothy, red-top and alsike clover. Frequently it is not practicable to drain it, and the question arises whether under such circumstances it is possible to improve upon present conditions and practices. In many such meadows red-top, *Agrostis vulgaris*, does well, and it should always be sown where it will grow. In the wetter places even this kills out soon, and the "swale" plants again predominate. Examination of the natural vegetation of such an area shows that it consists chiefly of various species of sedge, with rushes, blue flag and certain true grasses. These grasses may include numerous species, but the bulk of the true grass crop is made up of one or more of the following:—blue-joint, *Calamagrostis Canadenis*; the false red-tops or Glycerias, especially *G. nervata and G. grandis;* cut-grass, *Leersia oryzoides*; reed canary grass, *Phalaris arundinacea*; fowl meadow grass, *Poa flava*. It is a matter of common experience backed by chemical analysis that the true grasses are almost without exception superior as hay to the sedges or rushes. In fact, all of the above mentioned grasses rightly handled make excellent hay. It is evident, therefore, that it would increase the value of these wet meadows if such of these natural grasses as are best adapted for the conditions could be made to replace the sedges and other plants. The most valuable one for most places is fowl meadow grass.

There are large areas, especially along Otter creek, where, without any encouragement or seeding, this grass forms the bulk of the hay, which is highly prized by the owners of the meadows. An examination of these natural meadows near Brandon made several years ago under the guidance of Hon. C. M. Winslow, then secretary of the State board of agriculture, led to the belief that a more thorough study should be made of this grass, including its yield, seed production, ease of propagation, composition, palatability, soil adaptations, and ability to perpetuate itself in wet soil in competition with the sedges. Observations and experiments have been continued for seven years, and it seems time to publish the results.

HISTORICAL MATTER AND EARLIER COMMENTS

The early settlers of New England were obliged to depend on the natural grasslands for hay and pasture for their stock. They, therefore, observed the native grasses more closely and learned to appreciate their relative values better than most farmers do today. Jared Eliot[1] in certain agricultural essays written in Connecticut nearly two centuries ago says, "There are two sorts of grasses, which are natives of the country, that I would recommend. These are herd-grass [timothy] and fowl meadow . . .

1 Jared Eliot, Essays on Field Husbandry, Connecticut. (1748).

It is said that fowl meadow grass was brought into a meadow in Dedham by the ducks and other wild water fowl, and therefore called by such an odd name. Of these two sorts of natural grasses the fowl grass is much the better. It grows tall and thick and makes a more soft and pliable hay than herd's grass." Flint[1] says: "It makes an excellent grass for oxen, cows, and sheep, but it is thought to be rather fine for horses. It never grows so coarse and hard but that the stalk is sweet and tender and eaten without waste." Gould[2] writing in New York, in 1869, says: "I have found it to grow on almost every kind of soil: but it attains to the greatest perfection on a rich moist one . . . . It adds much to the value of a sward from its nutritive qualities and powers of early and late growth. As it perfects an abundance of seed it may be easily propagated."

Beal[3] writes as follows of fowl meadow: "It makes soft pliable hay of excellent quality. On account of the large top and slender stem it is rather inclined to lodge. This is one reason for growing it with other grasses, like red-top, which has larger and stiffer stems. The grass will grow on almost any rich, arable land, making a fair crop, but it likes moist land . . . . Pure seed is not found on the market. This constitutes one of the many practical reasons why farmers stick to a few well known sorts."

Other writers upon agricultural grasses in England as well as in America invariably speak well of it.

APPEARANCE, CHARACTER AND OCCURRENCE

Fowl meadow grass is one of the commonest and most widely occurring natural grasses in Vermont. One may expect to see it anywhere that timothy, red-top, or Kentucky blue grass will grow; but it is commonest in wet meadows and along streams and ditches, and it is only in these moist, rich soils that it reaches its best development. In such places it often covers large areas to the practical exclusion of other grasses. The largest tracts where this grass is in control are along Otter creek. Here there are extensive areas of natural meadows, which have never been plowed nor fertilized by man, but from which the hay has been removed annually since the earliest settlements. This land produces from one to two tons to the acre of excellent hay, and as a result is highly valued by its owners. The annual flooding of these low lands prevents the growth of timothy and clover and at the same time keeps them fertile. Along the smaller streams and in the natural meadows of the mountain valleys the areas occupied by it are less extensive, but it occurs in greater or less amount in almost every overflowed intervale or marshy meadow in northern New England.

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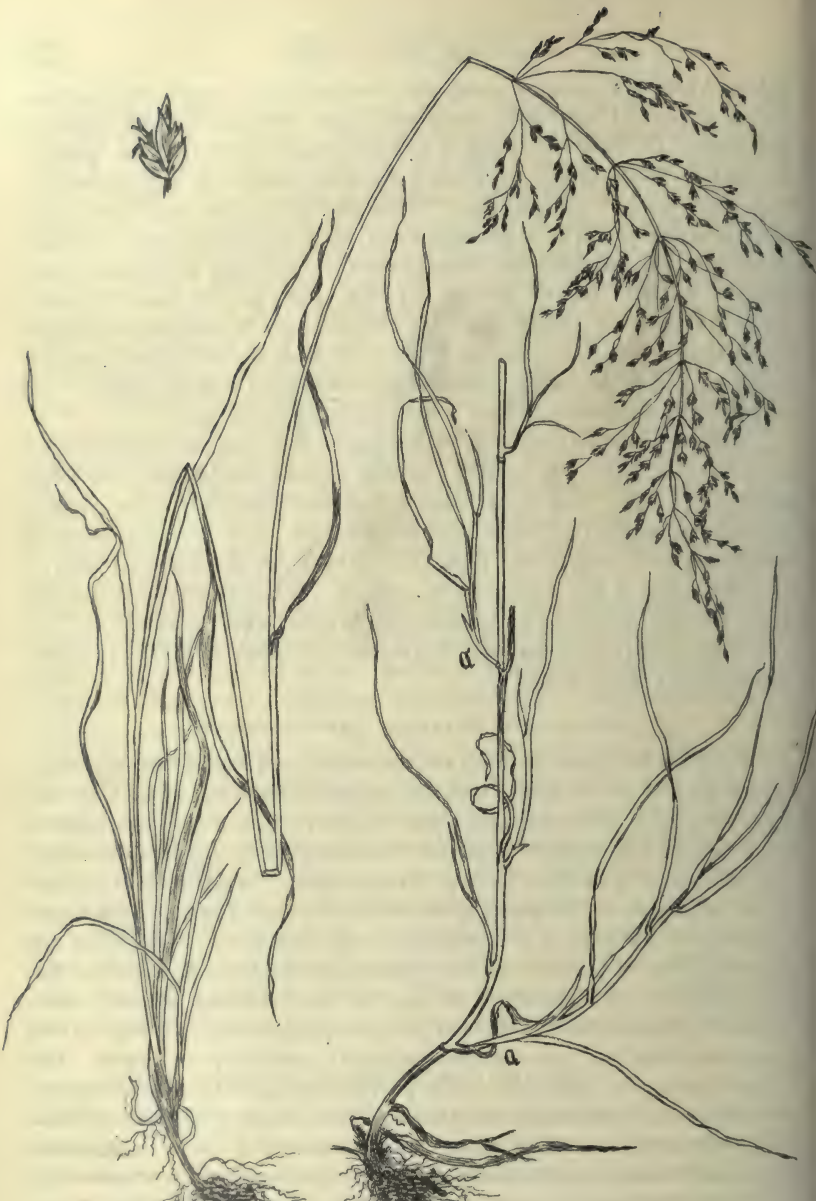
1 Grasses and Forage Crops, p. 84 (Rev. ed., 1888)

2 Gould, J. I., Trans N. Y. Agric. Soc., p. 296 (1869)

3 Beal, W. J., Grasses of N. A., I, pp. 140-2 (1887)



FOWL MEADOW GRASS

An entire plant in the flowering stage (July) at the left; a single cluster of flowers more enlarg above. At the right is the base of plant after seeding (Sept.) showing the development of new branc from the lower joints, at *a* and *a*. Drawn from nature, by Ella K. Herrick. Reduced one-half.

It is usually mixed with two or three other grasses which closely resemble it, and with which it is apt to be confused. The commonest of these is red-top (*Agrostis vulgaris*) and the larger false red-top (*Glyceria grandis*). The botanist easily distinguishes it from these by the character of the flowers. One who does not understand these finer structures will learn by a little observation to recognize it almost as certainly by the color and habits of growth. The flower clusters or "heads" of fowl meadow are always light green, whereas the "red-tops" are usually reddish. The red-tops, both true and false, have coarser, stiff upright stems, and the flowering heads are upright, with branches stiffly divergent; whereas the fowl meadow has a more slender stem, and the flower clusters tend to nod or droop on more slender branchlets. The accompanying figures may help to make this as well as some other characters clearer. The leaves of the fowl meadow are more slender and pliable than those of the "red-tops," and the leaves and stems remain green and excellent for hay even after the seed ripens. A marked peculiarity of fowl meadow, and one which adds much to its agricultural value, is that of sending up from each lower joint a fresh, leafy stalk, after seeding, See *a* and *á* in the figure.

This habit and its importance to the farmer were clearly described by Eliot. In his essays he says:[1] "The grass has another good quality which renders it very valuable in a country where help is so much wanting. It will not spoil or suffer, although it stands beyond the common times for mowing. Clover will be lost in great measure if it be not cut in proper season. Spear grass, commonly called English grass, if it stands too long will be little better than rye straw, ... but this fowl meadow grass may be mowed any time from July to October. . . . . This I wondered at, but viewing some of it attentively I think I found the reason of it. When it is grown about three feet high it then falls down, but doth not rot like other grass when lodged. In a little time after it has thus fallen down, at every joint it puts forth a new branch; but now to maintain this young brood of suckers there must be a plentiful course of sap conveyed up through the main stem or straw. By this means the grass is kept green and fit for mowing all this long period."

EXPERIMENTS OF 1894–1901

In 1894, when it was decided to attempt the cultivation of fowl meadow grass at this station, inquiries for seed were made of dealers in New York and Boston. There was little to be had, but one Boston seedsman sent a sample package, charging for it 25 cents a pound. This was such impure stuff and so evidently worthless that we decided to try collecting some. Hon. C. M. Winslow kindly undertook to do this from his natural meadow

1 Loc. cit.

and later he sent a sack of excellent clean seed, about one and one-half bushels, weighing some thirty pounds, for which he charged $5.00.

A piece of bottom land on the intervale of the Winooski river was used for the experiments. This area is subject to overflow each spring, and the timothy which had been sown a few years before had yielded to a mixed growth of sedges, flag and wild grass (considerable *Glyceria grandis*). Plots were sown in August to pure timothy ; to pure fowl meadow ; to a mixture of fowl meadow and red top ; and to a mixture of fowl meadow, red top, timothy and alsike clover. Another plot was sown to this last mixture in August, 1895, and in 1898 and again in 1900 plots were seeded similarly to those of 1894. Observations have been made and conditions and yields of fodder and of seed recorded from time to time since. The results and our conclusions therefrom are briefly summarized in the following paragraphs.

Seed production and weight.—The seed is small, but is produced abundantly, and it ripens uniformly. We have harvested seed usually in the last week of July. Where exact records have been made they have shown yields as follows :

In 1897 one-sixth acre, almost pure stand of fowl meadow from seeding of 1894 and 1895, yielded 1 bushel of seed weighing 19 pounds. This is at the rate of six bushels or 114 pounds to the acre.

In 1899 two square rods yielded 1.7 pounds of seed, which is at the rate of 136 pounds to the acre.

From these figures it is evident that the seed is yielded abundantly ; and one who learns to recognize the grass may easily collect it in almost any region of the state. The fact that the stems and leaves remain soft and green until after the seed matures has already been noted ; and the hay of this late cut crop from which our seed has been obtained is apparently as good and as well relished by stock as is that cut earlier.

The yields of hay and seed to the acre in 1899 were, seed 136 pounds ; hay, from which this seed was threshed, 4400 pounds, or 2 1-5 tons. It is evident, therefore, that if there were a demand for the seed at a fair price, say the same as Kentucky blue grass (10 to 20 cents a pound) it would be very profitable to grow the grass for hay and seed.

Growth from seed.—The seed so obtained is of excellent quality. It resembles closely that of Kentucky blue grass or "June grass," and like that is a light seed always enclosed in the "chaff." Fowl meadow is also like Kentucky blue grass, slow in establishing itself from seed. It has rarely made much of a stand the first year after seeding, hence we have succeeded best where it has been used in mixture with the quicker growing grasses which furnish the hay crop for the first year or two. In such mixtures the other grasses predominate the first year, and usually the second, but by the third season they have usually been drowned out by the floods or overgrown by the fowl meadow grass, and thereafter this latter has constituted

the bulk of the hay crop. For the past three seasons the plots seeded in 1894 and 1895, even when red-top was used in the mixture, have consisted of little else than fowl meadow, and the stand of this has continued to improve in both quality and yield as compared with that on the adjacent meadow land sowed to timothy alone. Discussions of the amounts and mixtures used and recommended for seeding are given later in this article.

Yield.—Jared Eliot stated in his essays that "it yields a good burden—three loads to an acre." Sinclair[1], an English experimenter, states that in his grass gardens he obtained the large yields of 6,654 pounds of hay to the acre from the fowl meadow grass when cut at the time of flowering, and 8,335 wheu cut at the time of ripening the seed. These figures are much above what may be expected ordinarily but are interesting as showing the possible yields under high cultivation, and especially the increased yield from late cutting. Mr. Winslow states that the yields from the natural fields of fowl meadow in the Otter creek valley are from one and one-fourth to two and one-half tons of cured hay to the acre, probably averaging one and one-half tons.

The returns from our experimental plots have naturally varied with the season, the soil and the mixture. In 1895 two plots were seeded, Plot I to a mixture of timothy, alsike clover, fowl meadow grass and red-top; Plot II, which was on adjoining but slightly higher land, was seeded to timothy. These fields have remained to the present time, the hay having been cut once each year, The red-top formed the bulk of the grass in plot I, for the first year. Since then the fowl meadow has steadily increased, and for the last three years there has been no trace of either timothy or red top in it. There was an excellent stand of timothy to begin with on plot II, but it has steadily weakened while the sedges and other swale plants have multiplied.

Yields have been recorded on areas from each plot representing as nearly comparable soil conditions as possible, as follows:

RELATIVE YIELDS OF TIMOTHY AND OF FOWL MEADOW, BOTH SOWN IN 1895

Date of cutting	Yields in pounds to the square rod			
	Fowl meadow		Timothy	
	Green	Dry hay	Green	Dry hay
July 23, 1896	—	40	—	32.5
July 7, 1898	96	51	78	40
July 30, 1899	52.5	29.6	48.5	27.5
July 19, 1900	59	28	43	24.2
July 28, 1900	54	40	39	22
July 17, 1901	—	29.5	—	18
Averages	68	36	52	27.3

1 G. Sinclair, *Hortus Gramineus Woburniensis.* (1826).

Some of these dates are late for haying, but were those when the main hay crop was cut on this low land. The only exception is the second cutting of 1900 on July 28, when the fowl meadow stood until the seed was mature. The exceptionally large yields of 1898 indicate that the hay was not as dry that year as the others. Since, however, the two plots were treated alike, the results are comparable.

A comparison of these figures shows a larger yield both of green matter and of dry hay from the fowl meadow plot than from the timothy plot each year. That is a less significant thing for the first two or three years when some red-top persisted in the fowl meadow plot and might be expected to add to the yield. The special significance lies in the returns of the last three years during which the fowl meadow grass has been fully established and has held its own ; indeed, it has shown a slight gain each of these years. During this same period the yield of timothy has steadily declined. Two things are evident; first, that the fowl meadow is distinctly better adapted than timothy to such low intervale land and that it even crowds out red top; second, that the fowl meadow is slow in establishing itself, but when once established is hardy and persistent.

A comparison of the yields of fowl meadow obtained from the two cuttings in 1900 as shown in the above table, is interesting and significant. It will be observed that the yield of dry hay increased over 40 percent between July 19 and July 28. The corresponding yields of green grass show that this was not a chance difference in soil conditions since the weight of the green crop was greater on July 19. As stated earlier, Sinclair, an English experimenter, made similar observations, viz : yield at time of flowering: green, 15,634 pounds; dry, 6,634; yield at time of ripening of seeds : green, 14, 973 ; dry, 8,235 pounds. To favor a comparison we reduce Sinclair's results and ours to a percent basis, taking the green weight at time of flowering as 100 percent.

	Yield of early cut hay		Yield of late cut hay	
	green	dry	green	dry
Sinclair's results	100	42.5	95.6	52.6
Vermont results	100	47.6	92	68

The parallelism is striking and shows that, in the absence of evidence of deterioration, it seems advisable to permit fowl meadow grass to remain until the seed is approaching maturity before it is cut. There is the belief among owners of fowl meadow grass lands that unless the grass is occassionally allowed to stand until after the seed falls the meadows run out[1]. It is evident that one will not lose in yield of hay by so doing.

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1 Mr. Winslow, in writing us about this, says : "One feature which I do not understand is that after a series of wet seasons the fowl meadow seems to be almost all run out by the coarse grass, and after a dry season or two it returns; and what surprises me is that the meadows that are kept ditched and those that are not seem to be about alike in this respect. I have heard it said that the meadows needed to have the grass remain standing once in a while to reseed, but I could never see that any accidental management in either direction on individual meadows had any influence either way. I sell a good deal of standing grass and some parties are slow in getting it off and it sometimes remains until the latter part of August before they cut it, while others harvest very early in July ; yet I can discover no difference in the after quality of the meadow. Parties usually take the same piece of meadow year after year so that it practically receives two kinds of treatments in adjoining plots year after year."

Composition and palatability.—Fowl meadow grass usually grows in its natural state in mixture with other less desirable "marsh grasses", sedges etc. For this reason it is not generally rated at its full value. Wherever it does occur in sufficient purity to permit a fair judgment, opinions are universally in favor of it. We have already cited the verdicts of several of the earlier experimenters (page 238). Mr. Winslow feeds much of it to dairy cows, as do others in this vicinity, and he considers it equal to his best upland hay. Mr. P. B. Cloyes, of Middlebury, is enthusiastic regarding it. He says that he prefers it to alsike clover hay for cows, basing his opinion on experience. When he has changed from fowl meadow to clover hay his cows fell away in yield and recovered when the fowl meadow was restored. This is of course an extreme comparison, but shows that this grass is in a high degree palatable as well as nutritious.

Mr. S. Stebbins of Johnson tells us that some twenty-five years ago he sowed fowl meadow on a low island of the Missisquoi river with splendid success, and that it proved the best of hay for horses. Similar opinions have come to us from other farmers.

We have made no exact feeding trials of fowl meadow hay although it has been fed to the cows several times and has always seemed to furnish an excellent forage.

The chemical composition as given below indicates that the food value of fowl meadow hay is practically the same as that of timothy. The former was cut July 23, 1898, and analyzed at this station. The analysis of timothy hay is inserted simply for comparison.

	Original substance		Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
	Water	Dry matter								
	%	%	%	%	%	%	%	%	%	%
Fowl meadow grass	49.41	50.59	4.95	6.65	34.02	52.48	1.90	1.06	0.26	1.17
Timothy hay	13.2	86.8	5.1	6.8	33.5	51.7	2.9	1.08	0.61	1.04

Mixtures for seeding low, wet soils.—As already indicated, fowl meadow is slow in establishing itself from seed, and we have always succeeded better when we have used it in a mixture with other grasses. We have tested these in various combinations and in varying proportions on different soils. The only kinds found profitable for the soils under discussion are alsike clover, timothy, red top and fowl meadow. The alsike will endure more water in the soil than will red clovers, and it is a longer lived plant. Timothy and alsike will grow for the first year or two in about equally moist

land, but the alsike weakens first. Red top will thrive in a much wetter soil than either, but this in turn yields to the fowl meadow in two or three seasons if the soil is wet and subject to overflow. The proportion of these four kinds should, therefore, be varied to meet the conditions of moisture in the soil. As an average mixture we advise:

Timothy,	10	pounds
Alsike clover,	6	"
Red top (recleaned seed)[1]	4	"
Fowl meadow (in chaff)	10	"
Total,	30	pounds

This amount will do for an acre of average soil, but the exact amount of seed as well as the proportions of the ingredients for best results will vary somewhat with conditions.

We have in all cases on our plots seeded in August, the earlier in the month the better, without grain or other "nurse crop." If land is dry enough to plant to corn we should advise seeding in the corn in July. Usually, however, the soil which is suited for fowl meadow is too wet in spring for corn land.

SUMMARY

The preceding discussion may be summarized as follows:

Grass is the chief crop of Vermont. But few kinds are commonly cultivated. None of these thrives on low, wet soils, which are consequently occupied by a natural growth of sedges and other plants and produce an inferior quality of "swale hay." Red top and alsike clover should be used more generally than they are on moist lands, but various good native grasses thrive on soils too wet for these, and such deserve to be encouraged and sown. Fowl meadow grass is the best of these. It now occupies large areas of flooded intervales and occurs in almost every marshy meadow or wet border. Its value for hay purposes has been recognized for two hundred years, and numerous careful observers, both farmers and botanical experimenters, have commended it. It closely resembles red top and other grasses commonly associated with it and is popularly confused with these. It may be distinguished by its softer texture, more slender habit and lighter color as well as by the character of the flowers. A second crop of flowering stems are produced at the nodes after seeding. Since the older stalks remain soft, green and palatable after seeding, the crop may be cut for hay at any time from July to October. This adds much to its value. Experiments conducted at this station during the last seven years have resulted as follows:

1 Red top seed occurs in two grades of purity; 1 pound of recleaned seed equals 3 or 4 pounds in the chaff.

Seed is produced abundantly and of good quality, yields ranging from 6 to 7 bushels to the acre, 19 pounds to the measured bushel. The hay from which this seed was threshed is almost as palatable as that cut earlier.

Growth from seed is easily obtained, but it requires two or three years for the grass to fully establish itself.

The yields from the natural overflowed intervale meadows of Otter Creek are one and one-fourth to two and one-half tons to the acre. In our plots they have been even greater, and have each year exceeded those from adjacent timothy plots. Moreover, the yield from the fowl meadow plots has shown a slight gain each year for three years past, whereas that from adjacent timothy plots has steadily decreased in quantity and deteriorated in quality, owing to the displacement of the timothy by the sedges.

The yield increases from the time of flowering to that of seeding, and since the quality remains good it is probably better to cut it rather late.

The hay is of excellent chemical composition, and is as well relished by stock as is the best upland hay.

For sowing in wet soils a mixture is recommended which may include variable proportions of red-top, fowl meadow, timothy and alsike clover. If the soil is favorable to it the fowl meadow will form an increasing proportion of the crop until the third or fourth year when it will have entirely replaced the other grasses and thereafter persists.

Sowing in midsummer without grain or other nurse crop is advised.

KILLING WEEDS WITH CHEMICALS

During the seasons of 1898, 1899 and 1900 trials were made of various chemicals for killing weeds.[1] Observations were continued during the summer of 1900 upon the plots treated in previous years and some additional trials were made of the more promising preparations upon a larger scale than heretofore.

I. CONDITION IN 1900 OF THE PLOTS TREATED IN 1899

The trials of 1899 were made by marking off weedy areas in gravel walks, roadways and tennis-courts, and applying to these various chemicals, dry or in solution, to compare their herbicidal value. The following chemicals were included in these trials: salt, copper sulphate, sulphide of potassium, kerosene, arseniate of soda, carbolic acid, a mixture of white arsenic and sal soda, Henderson's fluid weed destroyer or herbicide, and Smith's weed-killer.

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1 Vt. Sta. Rpt. 12, p. 182 (1899); also Rpt. 13, p. 282 (1900)

The amounts and methods of application and strength of solutions, are discussed in detail in the report cited[1]. The value of a chemical weed killer for certain situations, such as walks, gutters and tennis-courts, depends in part upon its immediate action, but even more upon the length of time that it will continue to hold vegetation in check. For other situations the conditions may be exactly reversed, as when one wishes to destroy noxious plants in a lawn or other soil where it is desired to have grass or similarly useful plants develop in a short time. Here one seeks a chemical which will act promptly, and then because of evaporation, solution or other cause cease to act. From the former experiments it was concluded that salt, copper sulphate, potassium sulphid, and kerosene were not generally practical or economically effective as weed killers, although some of these might be useful in special cases, e. g. salt, when cheap enough. Our observations this year have not caused us to alter our conclusions in regard to the above preparations. Five compounds were found to have distinct value in previous experiments, and the following observations are based upon the condition in 1900 of the plots treated respectively with each of these five in 1899.

Carbolic acid.—This is emphatically the least lasting in its effects. It is very quick in its action, but does not penetrate deeply enough into the soil to kill the underground parts of weeds. The indications are that its poisonous qualities do not last as long as its odor. A year after application the plots where this had been applied freely were no less weedy than untreated areas near by. These conclusions are entirely in accord with our further experiment in 1900 recorded later in this article.

Arsenic-sal-soda mixture.—This was very slow in its action, but its effects are quite lasting, being plainly visible one year after application.

Smith's weed killer.—Some of the areas treated with this preparation in 1899 were perfectly free from weeds one year later. The rest of the ground plainly showed its lasting effects. It was less uniform in its action than some of the other poisons.

Arseniate of soda.—This was in our plots somewhat more effective and lasting than any of the preceding preparations. Since we used it as offering a convenient substitute for the arsenic and sal soda mixture and found it much more convenient to handle and a little more effective in its action, and now find it more lasting in its effects, the results are gratifying and lead us to commend it even more strongly than in our former report.

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1 The strengths of these solutions found most profitable in the trials of 1899, and the ones used in the trials of 1900, unless otherwise specified, were as follows, in all cases 8 gallons of the solution being applied to the square rod : crude carbolic acid, one quart in 8 gallons of water ; arsenic-sal-soda mixture, white arsenic, 1 pound, sal soda, 2 pounds, water, 9 gallons; arseniate of soda, 1 pound in 8 gallons of water.

Henderson's fluid weed destroyer or herbicide.—Considerably over one-half of the ground upon which this mixture was used was absolutely free from weeds one year later. The rest of the ground showed but few plants. This is, therefore, the most enduring weed destroyer we have used.

II. FURTHER TRIALS OF HERBICIDES IN 1900

Trials were made on a comparatively large scale upon the university tennis courts of carbolic acid and sodium arseniate solutions, and on a smaller scale of sulphuric acid. The soil is a clay loam, and, of course, closely packed. Most of the weeds were seedling annuals, two inches or less in height; there were, however, scattering plants of the more deeply rooted kinds,—knot grass, witch-grass, etc. The results, briefly summarized, are as follows:

Sulphuric acid.—A solution was made of one part by measure of commercial sulphuric acid in 40 parts of water, and this was applied at the rate of 8 gallons to the square rod. The parts of the weeds above ground were killed, but not those under ground. The plants soon recovered. The sulphuric acid killed only those parts with which it came into immediate contact. Presumably, it forms some insoluble compound as soon as it soaks into the soil and its action upon the plants is thereby lessened or entirely checked.

Our recent trial of this acid upon the orange hawkweed[1] gave results similar to the above and led us to conclude that it was of less value than common salt in destroying that plant. We doubt, therefore, whether this acid is ever to be recommended as a weed killer, since it is less enduring than the arsenical poisons and less penetrating than the carbolic acid. The absence of odor is the only thing to commend it above the carbolic acid.

Carbolic acid vs. sodium arseniate.—These two chemicals were tried in 1900 on a large scale upon the tennis courts. The courts had been cleaned with the hoe in the early spring and at the time of beginning these trials had again become weedy, mostly with seedling plants less than one inch high. The first applications were made July 18, using the strength of solutions recommended in our earlier report. (See footnote page 248). There were some showers during the next few days which may have somewhat reduced the effects of the carbolic acid, but which seemed to help the action of the sodium arseniate. The action of the carbolic acid was immediate, while it took the sodium arseniate several days to show its effects. Both solutions killed the seedlings ultimately.

The arseniate plots were free from weeds by July 27, except for some old plants of witch-grass and knot-grass, and these appeared to be dying. A new crop of seedling weeds had appeared upon the ground treated with

1 Vt. Sta. Rpt. 13, p. 282 (1900).

carbolic acid. These differed from those on adjacent untreated areas by only about the growth of a week, thus showing that the carbolic acid was not at all lasting in its effects.

Another application of carbolic acid was made on August 1 to the same plots, but the application of sodium arseniate was not repeated. The effect of the acid was as before to kill the seedlings.

The carbolic plots had again recovered by October 1 and were very weedy, although in a little better condition than was the untreated ground. The sodium arseniate plots were practically free from all annual weeds and knot-grass, and although the deep rooted perennial plants like witch-grass had not all been killed, those that had survived were of a stunted growth.

These results indicate that by the use of one application of sodium arseniate or of several of carbolic acid annually it is possible to prevent the growth of annual plants and of all weed seedlings, upon tennis courts or similar areas. Large or perennial rooted plants can be severely checked, but not always entirely killed.

III. GENERAL CONCLUSIONS

As a result of all our experiments to date, therefore, we are led to the following conclusions:

Gravel walks, drives, tennis courts and similar places can be kept free from weeds by the use of certain chemicals.

The relative value of a chemical for such purpose depends on two things; first, its immediate action as an herbicide; second, the persistence of its effect. A single application each year should suffice with a good herbicide.

When both of these factors are considered the arsenical compounds are far superior to any other chemicals tried. These trials have included salt, copper sulphate, potassium sulphid, kerosene, carbolic acid, sulphuric acid.

The arsenical compounds tested were as follows, named in the order of their merit, (see details regarding solutions, footnote page 248): Henderson's fluid weed destroyer, arseniate of soda, Smith's weed-killer, arsenic-sal-soda mixture. The chief difference between these lay in the persistence of their effect, but all of them endure well, namely, for one year or longer.

In choosing between these, cost, convenience and effectiveness are to be considered. The cost is as follows, using eight gallons to the square rod:

Henderson's weed destroyer, $1.25 per can, to be diluted to 25 gallons; cost of treatment, 40 cents to the square rod.

Arseniate of soda, one pound at 11 cents, to be dissolved in eight gallons of water; cost 11 cents a square rod.

Arsenic-sal-soda mixture (white arsenic 6½ cents a pound ; sal soda 1¼ cents a pound) ; costs about 8 cents a square rod.

As to convenience, Henderson's is most convenient since it is liquid ; arseniate of soda is scarcely less so, since it is easily dissolved ; arsenic-sal-soda mixture is somewhat inconvenient to prepare.

As to effectiveness, we have previously stated that all are good, but so far as there is a difference, chiefly in their endurance, we rate them in order of excellence : first, Henderson's ; second, arseniate of soda ; third, arsenic-sal-soda.

Considering all these factors we should advise as follows : For small areas, in places where expense is not taken into consideration we recommend Henderson's weed destroyer, since it is both most convenient and most effective. For larger areas where convenience and economy are taken into consideration, we recommend arseniate of soda.

Where one has a large area to cover, the arsenic-sal-soda mixture is enough cheaper to make its use profitable in some cases.

For killing weeds in lawns or similar places where it is desired that useful plants shall occupy the treated soil as soon as possible thereafter, crude carbolic acid is the most generally useful chemical, since it is prompt in its action, and does not permanently poison the soil. Sulphuric acid comes next, but it is less penetrating. Its only advantage as compared with carbolic acid is that it is not malodorous.

Common salt is inferior to any of the above chemicals for miscellaneous weed killing. Its use on walks or roadways may be advisable in exceptional cases, when it costs little or nothing, but not if it has to be bought at usual market prices. Salt is, however, the best chemical for destroying the orange hawkweed in grass lands, and its use for that purpose is strongly recommended.

THE BIRD VETCH OR WILD PEA

(*Vicia Cracca*)

This plant occurs frequently in the meadows of Vermont, and in some places it is increasing so rapidly as to cause alarm. Frequent inquiries are made of the Experiment station regarding its qualities. Farmers hold widely different opinions regarding it. The majority consider it to be a troublesome weed, but some regard it as a desirable forage plant. One man said he wished his entire meadow was covered with it, while another correspondent says that in his experience this vetch rivals witch grass for the first place as a weed pest.

Description and occurrence—It is a member of the pea and clover family, with clusters of numerous small blue blossoms, followed by small pea-like pods. It is a close relative of the cultivated vetch (*Vicia sativa*).

Like all the clovers and vetches it has root tubercles, which indicate its ability to utilize atmospheric nitrogen and so enrich, rather than exhaust, the soil on which it grows. It passes under a number of popular names,—bird vetch, blue vetch, wild vetch, wild pea, French pea. It is a native of the woodlands of eastern America, but as it now occurs in Vermont it is most common in meadows and fence rows, and thus appears like an introduced plant. It likes best a strong heavy soil, such as favors timothy, and develops most luxuriantly in the Champlain clays of Addison county. In such soils it establishes itself in meadows and forms tangled circular patches where it smothers out the clover and timothy and each year extends the area of its dominion. In such a patch the growth is most luxuriant at the margins. It spreads by means of creeping stems, and it is this habit which makes it difficult to eradicate. Since it is a member of the clover family it might naturally have qualities to commend it. The agrostologists of the Department of agriculture state[1] that this species is cultivated in Europe, both for soiling and for hay, and that it is prized in German sheep pastures. Evidently basing their opinion upon European practices, they recommend its cultivation in low meadows, and especially in open woodlands.

From our own observations and the opinions of farmers it has seemed worth while to learn more accurately its value as a forage plant under Vermont conditions, since it frequently happens that a plant economically valuable in one country is not so in another. To do this it was necessary to determine its yield, composition, palatability, relation to other foreign plants in mixture and ease of eradication.

There was quite a quantity of vetch growing with timothy in 1900 in a field adjacent to the experiment farm. By marking out plots in different parts of the field there was opportunity to compare yields and shrinkage by drying, both of timothy and of vetch, under the same conditions of soil and weather. The plots selected appeared to be almost pure vetch, before cutting, but, as indicated in the table below, the plant is deceptive both in appearance and in yield. Plot IV was pure timothy, plot II before cutting appeared to be nearly pure vetch, but when cut was found to be fully one-half timothy, the vetch having so overrun the timothy as to hide it until cut. Plot I contained the most vetch, but as it was wet when cut the green weight is not strictly accurate. There was less vetch in plot III. All were cut on the morning of July 10.

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1 U. S. Dept. Agr., Div. Agros. Bul. 2, p. 50 (1896); and Circular 6 (revised) p. 8 (1898).

The conditions found are represented below in tabular form:

Plots	I	II	III	IV
Actual area	13 sq, rods	6 sq. rods	14 sq. rods	1 sq. rod
Composition of crop*	75% V., 25% T.	50% V., 70% T	30%V.,70%T.	100% T.
Yield per sq. rod, green	43 pounds	66 pounds	53½ pounds	58 p.
Yield per sq. rod, dry (hay)	12 pounds	25½ pounds	34 pounds	34½ p.
Percent loss in drying	72%	61%	36%	40%

* In the line stating composition V indicates vetch, and T indicates timothy.

Our observations coupled with these results justify the following conclusions:

The vetch is a deceptive plant, the yield, green weight, is much less than the appearance of the growing plants would lead one to expect, and the shrinkage in drying is great. Where the vetch occurs in timothy fields it reduces the yield by a large amount, viz: 30 to 60 percent in our plots. Moreover, in the places where it occurs it forms such a thick mat above that it smothers the leaves below, and at the same time holds moistture. As a result, in a vetch covered area the lower portions of the plants, both of vetch and of grass or clover that may be growing with it, are black and musty, and this injures both quality and appearance of the hay. Farmers who use the hay tedder complain that the tangled masses of vetch become a nuisance.

These objections would not hold against it as a pasture plant, but it rarely if ever occurs in Vermont hill pastures. The lower, heavier soils where it does occur in quantity are, of course, rarely pastured, so that we have no basis for opinion as to its value for pasturage.

Composition and palatability.—The universal testimony of farmers having the vetch in their hay is that it is relished by stock and that it appears to be in no wise objectionable in the hay, except as noted in the last paragraph. Some say that they consider it as good as clover for feeding. The hay made from the plots cut in 1900 was fed to cows at the experiment farm in comparison with mixed timothy hay. It was relished by the stock, did not appear to give any bitter taste to the milk, and was considered good hay by those in charge of the feeding.

A sample of the vetch hay was given to the station chemist in February, 1901, which was taken from that cut on July 10, 1900. The composition was found to be as follows. For purposes of comparison the composition of an average quality of clover hay is given also.

	Original substance		Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
	Water	Dry matter								
	%	%	%	%	%	%	%	%	%	%
Bird vetch hay	7.30	92.70	6.33	12 92	29.83	48.72	2.20	2.06	0 42	1.90
Red clover hay	15.30	84.70	7.32	14.52	29.25	44.98	3.90	2.33	0.45	2.60

Its weedy habits.—The thing that is most against the record of vetch is its weedy habits. It does not mingle peacefully with neighboring plants, but tends to overtop and smother them. This is decidedly to its discredit as compared for example with the related clovers and alfalfa. Moreover, it spreads by underground root-stocks and and it has the reputation, especially in Addison county, of being difficult to eradicate. Probably this depends somewhat on soil conditions, and still more upon the method of crop rotation.

There was considerable vetch in two fields of the experiment farm when the land was bought. This soil is a heavy clay loam, and it had lain in grass for a long time. These fields have since been brought under a system of short rotation of corn, oats and grass, and the vetch has been subdued without special effort.

Conclusions.—Our conclusions regarding this vetch as it occurs in Vermont may then be summarized as follows: It is of frequent occurrence in meadows, especially in clay soils. It is a member of the clover family, has root tubercles, and therefore tends to enrich the soil where it grows. It is a deceptive plant,since it appears to form a dense growth and to promise a heavy yield of hay ; whereas it actually gives a much smaller yield than pure timothy, and, of course, still less than the clovers. It tends to make the hay dark colored and musty, and because of the tangled masses bothers with the hay tedder. Where well cured it makes excellent hay, comparable to the clovers, both in palatability and composition. It spreads quite rapidly both by seed and creeping rootstocks, especially in clay soils, and smothers the timothy and clover. It is said to be difficult to eradicate in some soils, although on the experiment farm it was promptly and easily killed where short rotation and clean cultivation were practiced. On the whole we rate it as a weed rather than as a useful plant, and recommend its eradication rather than its encouragement.

TWO WEEDY PLANTS NEW TO AMERICA

(*Berteroa incana* and *Lathyrus tuberosus*)

Almost all of the bad weed pests of New England are plants imported from Europe. In some cases these have been introduced as cultivated plants of garden or field. The orange hawkweed, chicory and blue thistle (viper's bugloss) doubtless came in this way. Many others like the Canada thistle, quack grass and the kales were brought with imported grass or grain seeds. In most cases these imported plants have given more trouble as weeds in America than in Europe. Such experiences teach the importance of guarding against further accessions to our flora of suspicious foreign plants. It is considered one of the duties of the botanical department to aid in this police service, and we accordingly report the following recent additions to the state flora with their present status.

The hoary alyssum. (*Berteroa incana* DC).—This is a member of the mustard family closely related to the sweet alyssum of the garden. It is however, a perennial plant which grows one to two feet high. It was first brought to the Experiment station some six years ago by Miss Phebe Towle, who found it in a lawn in Burlington. It has since been found in other places by the roadside near Essex Junction. It produces seed abundantly and grows persistently in grass kept cut by the lawn mower. There is nothing about its behavior as yet however to cause alarm.

It has not been found elsewhere in this state. When first found at Burlington it had not been previously reported from the United States. It has, however, since been found in several places and appears to be spreading.

The tuberous sweet pea. (*Lathyrus tuberosus* L.)[1] —Specimens of a pretty sweet pea were recently sent to us from Vergennes by Miss Ruth Fisher. It seemed to be *Lathyrus tuberosus*, and this identification was confirmed by the botanists of the Department of agriculture. The plant has not heretofore been recorded for America, at least apart from cultivation. It is a native of Asia and eastern Europe. It has a fragrant pink blossom, closely resembling the garden sweet pea except that it is about two-thirds as large. It differs from this sweet pea, however, in that it is a perennial with creeping rootstocks which bear numerous tubers. The plant also produces seeds abundantly and because of its hardiness and its persistent spread in this locality it deserves to be watched closely. Miss Fisher has had the plant under observation for some ten years. She states that but few plants occurred in each of two places in the meadow when she first saw it. Since that time it has continued to spread over the field which has a moist and rather heavy soil until it is well scattered over several acres

1 See also note by L. R. Jones in Rhodora 3, p. 230 (1901).

and for a distance of forty rods. The land has meanwhile been under cultivation a part of the time with corn and potatoes and is now reseeded to grass. Owing doubtless to its rootstocks and tubers the plant not only persisted but spread under such treatment. The owner of the land has, as a result, become considerably alarmed by it and promises to take radical measures to eradicate it. The plant grows in dense mats as does the bird vetch, *Vicia Cracca*, and like this latter it smothers the grass and clover where it occurs. Stock seem to relish it in the hay.

The mode of introduction of the plant is a mystery. The location precludes the idea that it is a garden escape. Some horses were imported to this farm from Paris a decade ago and the most plausible theory is that the seeds were brought in the feed with them.

There is nothing in the occurrence or behavior of this plant as yet to cause serious apprehension, and its further behavior will be watched.

The unexpected and unexplained appearance of such foreign invaders in our fields should at least warn us to be always on the watch for strange plants. If they show any weedy tendency specimens should be sent to the Experiment station for identification.

REPORT OF THE BOTANISTS

L. R. Jones and W. J. Morse

In accordance with the plan of the later of the preceding reports of this department no attempt is here made to cover all the work of the year. Much of this is not sufficiently advanced to justify publication and on the other hand some of the results here published are based upon work antedating the current year. The subjects presented for consideration are as follows:

Potato diseases and their remedies.

- I. Potato blights as they occurred in 1901 and 1902.
- II. Results from spraying potatoes in 1901 and 1902.
- III. Relation of date of digging to development of rot.
- IV. The effect of top-pruning potatoes.
- V. Potato scab experiments of 1901 and 1902.

Orchard diseases and their remedies.

- I. Scabbing and russeting of apples in 1902.
- II. Studies upon plum blight.

The cultivation of the locust-tree.

Killing weeds in lawns.

POTATO DISEASES AND THEIR REMEDIES

I. POTATO BLIGHTS AS THEY OCCURRED IN 1901 AND 1902

A discussion of the annual occurrence of potato blights has formed a part of the report of this department for a number of years. The lateness of the issuance of this volume enables us at this time to bring this statement fully up to date by including the discussion of the current year, 1902, in addition to that of the previous season, 1901.

The amount of damage in 1901 from leaf eating insects (Colorado and flea beetles), from arsenical poisoning, from the early blight fungus (*Alternaria Solani*) and from tip burn was about as on the average of preceding seasons and calls for no special comment. In 1902, owing to the remarkably cool and wet weather, the insects were much less destructive. There was also less than usual of the leaf-spotting by the early blight fungus. This fungus is evidently more prevalent on the warm dry soils and in warmer summers in Vermont. Tip-burn is always associated with hot dry weather and was of no practical consequence in 1902.

The feature of peculiar concern in both 1901 and 1902 was the prevalence of the late blight and rot due to the fungus *Phytophthora infestans*. This has been true of all northern New England and adjacent Canada. It is noteworthy as indicating that the destructive occurrence of this fungus goes, as it were, in waves, and that its extent, distribution and time of serious outbreak in one season is as clearly related to the disease conditions of the preceding season as to those of weather and of soil. The climatic and other conditions of 1900 were such that there was little evidence of the leaf blight; but some dry rot occurred in moist soils. Therefore there was only a moderate amount of the fungus in the fields in 1901 as carried over from the preceding year. The appearance of the blight on the leaves was first observed at Stowe about the tenth of August, when it was well established but not beyond control by prompt spraying. It was found at Burlington and other points in the Champlain valley during the next few days and by August 20 might have been found in the majority of the potato fields of the state. Fortunately the dryer weather of the latter half of August and of September prevented its continuous rapid spread. As a result the occurrence and progress of the leaf blight did not attract unusual attention, although the fungus was everywhere present, growing slowly but persistently on the leaves. The conditions were, therefore, ideal for a continuous showering of the soil with the spores and, consequently, for the infection of the tubers. The result was an unusual and, to many farmers, an unexpected amount of rot. On the unsprayed portion of the Experiment station plots this reached in some cases as high as 65 percent. This was on a ridge with a good surface drainage. Low fields where the soil was wetter came under our observation where fully 90 percent of the tubers showed rot at the time of digging. The extent of the loss from rot of the tubers in proportion to that of leaf blight due to this fungus was therefore greater than we have heretofore observed it. It is safe to state that there was more general infection of the seed-tubers planted in Vermont in 1902 than has occurred for some half dozen years. Such being the case, climatic conditions favorable to the fungus were sure to lead to a serious outbreak of the disease; and such conditions occurred.

In 1902 the weather was remarkably cool and moist up to about August first, and it has continued cool and with a more than usual amount of rainfall since. The first leaves showing the blight were collected July 13, which is nearly a month earlier than observed in 1901 and, indeed, is the earliest date recorded in our observations of a dozen years. From this date it spread insidiously in the fields of early potatoes under closest observation during the next two weeks so that by

August first it was widespread on the lower leaves although not as yet very conspicuous. In some other pieces of earlier potatoes on moister soil the foliage was badly blighted by the last week of July while on later planted ones on dryer soils the development did not begin until early in August. From this time on the spread was rapid and conspicuous. The vines of early potatoes went down during the first half of August and the later ones generally succumbed during the last half. Owing to the wet spring, planting was generally delayed until unusually late, most of it being done in June. Obviously the normal development of the crop required a healthy foliage well through September; but a canvass of the vicinity of Burlington on August 2? showed the plants in two-thirds of the fields entirely dead and in the balance rapidly dying. The weather following was less favorable to the blight and some of the plants lingered for a week or even longer but made no more healthy growth except where sprayed. Digging revealed a large amount of rot on the moister soils. The conditions are accordingly favorable for the destructive occurrence of the rot again in 1903 providing next summer be not an unusually dry one. The two practical steps to lessen the danger to the next crop are: First, the selection and saving of seed from the earlier planted crop on light dry soil, that there may be as little of the fungus as possible introduced with the seed potatoes; and, second, preparations beforehand for promptly and thoroughly spraying the plants with bordeaux mixture. As shown in the following article, this again proved a practical remedy for the leaf blight and reduced the amount of rot in both 1901 and 1902.

II. RESULTS FROM SPRAYING POTATOES

RESULTS FROM SPRAYING IN 1901

These experiments were carried out on three different plots as follows:

Plot I. Bug death compared with bordeaux-paris-green mixture.

Plot II. Spraying twice with bordeaux-paris-green mixture compared with spraying once.

Plot III. Spraying twice with bordeaux-paris-green mixture compared with using paris green alone.

Plots I and II were laid out in the main potato field of the Experiment farm. The soil was a medium clay loam upon which no potatoes had been grown for several years; variety, Delaware; planting done the last of May. Plot III was laid out in a potato field upon an adjacent farm, soil similar to plots I and II.

PLOT I. BUG DEATH.

July 20 the potatoes were treated as follows: row 1, bug death in water applied with a hand sprinkler at the rate of 25 pounds per acre; row 2, bug death applied dry with perfection sifter at the rate of 112 pounds per acre; rows 3, 4 and 5 sprayed with standard bordeaux-paris-green mixture (1½ pounds copper sulphate, 1 pound lime, 2 ounces paris green, 10 gallons water).

At the time of spraying there were a large number of young Colorado potato beetles upon the vines. The following day nearly all the beetles had disappeared from all the rows. August 23 the potatoes were treated as follows: row 1, bug death in water applied with hand sprinkler at the rate of 25 pounds per acre; row 2, bug death applied dry with perfection sifter at the rate of 62 pounds per acre; rows 3, 4 and 5 sprayed with standard bordeaux-paris-green mixture. This time the vines were again quickly cleared of the potato beetles. There was no noticeable difference in the appearance of any of the rows, those treated with bug death being as free from insect injuries, tip burn, etc., as those sprayed with bordeaux mixture. Two weeks later the rows treated with bug death were badly affected by late blight and somewhat by early blight, while those sprayed with bordeaux were blighted much less. Row 1, which had received the lighter application of bug death in water was blighted worse than row 2, on which it was applied more freely and dry. The blight continued to spread so that rows 1 and 2 were dead some time before 3, 4 and 5. The potatoes were dug October 8, at which time practically all the vines were dead. The results are given in the following table:

	PLOT I.	Yields of potatoes of marketable size in bushels per acre			
Row number	Treatment	Sound	Rotten	Total	Percent rotten
1	Bug death in water	63.	131.	194.	67.
2	" " dry	66.	112.	178.	63.
3	Bordeaux-paris-green mixture	155.	81.	236.	34.
4	" " " "	157.	66.	223.	30.
5	" " " "	140.	67.	297.	32.

Discussion of results.—The conclusion reached was that bug death applied in such liberal amounts either dry or in water rids the plants of the Colorado beetles and lessens the injury from the flea beetles and other insects. The amount used, however, was in all cases exces-

sive, (on row 1 at the rate of 50 pounds per acre, on row 2 at the rate of 174 pounds) and so the test had no significance in deciding whether this powder is or is not an economical substitute for paris green or other arsenites. This was not the purpose of the experiment and the above conclusion was only reached incidentally. The primary object was to determine whether bug death has value as a *fungicide* in checking the blight and rot. The excessive amounts were used in order to give it the best possible opportunity to show such protection. The results were certainly conclusive on this point. Bug death even in excessive amounts, as here employed, (50 and 174 pounds per acre) *did not prevent the blight or rot.* Its inefficiency as a fungicide is evident by reference to the fact that the rot amounted to over 121 bushels per acre or almost two-thirds of the crop where this was used. It is claimed that it is a plant food. In view of this it is significant to compare the average total yield of rows 1 and 2, 186 bushels per acre, where the bug death was used, with the average of rows 3, 4 and 5, 252 bushels per acre, where bordeaux mixture was applied. Neither compound is a plant food in any ordinary sense and any gain from their use is attributable to the indirect benefits from protection against parasites. Neither of them has any more claim to the title of plant food than has paris green.

PLOT II. BORDEAUX-PARIS-GREEN MIXTURE

This plot gave an opportunity to compare the results from two applications of this compound with those from one application. On July 20 all the rows in the plot were sprayed alike with standard bordeaux-paris-green mixture. August 24 rows 1, 2, 3 and 7, 8, 9 were again sprayed, while rows 4, 5 and 6 were left unsprayed.

Two weeks later the rows sprayed once were nearly dead, while those sprayed twice were still green and growing. The difference was due chiefly to insect injuries and late blight. The blight continued to increase upon the vines sprayed once and they were entirely dead before the middle of September whereas the rows sprayed twice continued green well through this month and were not all dead October 8, when the last were dug.

The yields, expressed in bushels per acre, are shown in the following table:

PLOT II

Row number	Treatment	Large sound	Large rotten	Small	Total	Percent rotten
1	Sprayed twice, July 20, Aug. 24	190.8	16.5	17.2	224.5	8
2	" " " "	199.1	14.6	15.3	229.0	7
3	" " " "	140.0	26.7	14.9	181.6	16
4	Sprayed once, July 20,	32.9	101.0	7.5	141.4	75
4*	" " "	62.6	69.0	7.6	139.2	52
5	" " "	51.0	94.1	13.9	159.0	65
5*	" " "	66.1	73.0	20 4	159.5	52
6	" " "	56.2	75.0	10.6	141.8	57
6*	" " "	57.0	64.5	12.7	134.1	53
7	Sprayed twice, July 20, Aug. 24	163.2	3.5	13.9	180.6	2
7*	" " " " *	159.2	13.0	8.5	180.7	8
8	" " " "	172.7	8.9	15.5	197.1	4
8*	" " " "	171.0	17.8	10.4	199.2	9
9	" " " "	175.6	7.0	12.1	194.7	3

Discussion of results.—The single application of bordeaux-paris-green-mixture protected the plants somewhat against insect attacks but was evidently of little avail against the late blight and rot which was at its worst a month later. It was the second application, made August 24th, which held this in check. The following statement of the average yields (large tubers) and of the amounts of rot will make this plainer.

	Sound.	Rotten.	Total	%rotten
Sprayed July 20 and Aug. 24 (rows 1-3, 7-9).	170.0	13.5	183.5	7
Sprayed July 20 (rows 4-6) ..	54.3	79.5	133.8	60

From this it is seen that about fifty bushels per acre was added to the total yield by prolonging the life of the vines as a result of the second spraying, and sixty-six bushels by checking the rot. A comparison with the gains from bordeaux-paris-green spraying in previous seasons is given later in this article.

PLOT III

This experiment was not carried on at the experiment farm which will account for some of the difficulties met with, and for the small yields.

The soil was a heavy clay loam. The variety of potatoes used was unknown. The crop was hoed only once and the field became overrun with weeds, mostly pigeon grass.

On July 30 rows 1, 2, 3, 7, 8 and 9 were sprayed with standard bordeaux-paris-green mixture, while rows 4, 5 and 6 were treated with paris green and lime applied with a hand sprinkler. At the same time

* Rows marked with a star (*) were dug Sept. 27, all others Oct. 8.

the owner sprayed the rest of the field with bordeaux mixture; but so small an amount was used as to produce little effect.

On August 19 all the rows were treated the same as before, except that a heavier application of bordeaux was used. At that time the rows sprayed by the owner were nearly all dead from tip burn, insects and early blight.. Those treated with paris green were likewise dying or dead from the same causes, while those sprayed with bordeaux mixture by the station were green and growing.

Three weeks later all the vines were dead, except those sprayed by the station, (1, 2, 3, 7, 8 and 9). These continued green until September 30, at which time all were practically dead. At this date they were dug. Very little rot was found, there being only nine rotten tubers in row 4, seven in row 5, and four in row 6. These were all found in a few adjacent hills. Unfortunately no record was made of those sprayed by the owner. The table shows the results of those treated with standard bordeaux-paris-green and those treated with paris green and lime.

Row. number.	Treatment.	Yield in bushels per acre.	
		Large tubers.	Small tubers.
1	Two applications bordeaux,paris-green mixture,	80.7	13.8
3	Two applications bordeaux-paris-green mixture,	95.5	15.9
3	Two applications bordeaux-paris-green mixture.	110.2	18.0
4	Paris green	69.0	24.4
5	Paris green	64.8	20.2
6	Paris green	57.3	19.1
7	Two applications bordeaux-paris-green mixture,	104.0	24.4
8	Two applications bordeaux-paris-green mixture,	112.5	32.9
9	Two applications bordeaux-paris-green mixture,	116.8	38.2

Average yield, large tubers, where bordeaux-paris-green was used..127 bu.
Average yield, large tubers, where paris green alone was used........84 bu.
Gain, 43 bushels per acre or 51 percent.

Discussion of results.—This trial has little significance beyond further demonstrating that the proper use of bordeaux mixture on potatoes is a very profitable operation. In many cases, however, the work is only half done as it was by the owner of the potatoes in this field. It is then of little value.

RESULTS FROM SPRAYING POTATOES IN 1902.

It did not seem advisable to make comparative tests of fungicides this year. We have hitherto shown the superiority of the freshly prepared bordeaux mixture over all others and have at the same time showed that ready made bordeaux mixtures have distinct value. The

only purpose in spraying the tops experimentally the present summer was to keep up the serial records as to the gain from the use of bordeaux mixture. The opportunity for this was presented in the main potato field at the Experiment farm. The potatoes were Delaware planted about May 15, on a moist sandy loam. The sprayings were made August 1 and 20, using the standard bordeaux mixture (1½ pounds sulphate, 1 pound lime, 10 gallons of water). The potatoes were dug October 10 and the sorting done at this date. The character of the soil was not as uniform as desirable, so that more confidence is to be placed in the final averages than in the detailed comparisons, row by row. The details are, however, given in the following table, there being three rows in each plot, except III, where there was but one row, and VI, where there were four rows. The figures represent pounds per row.

			Total yields by rows		Average yield of plots		
Plot	Treatment	Row	Sound	Rotten	Sound	Rotten	Total
I	Not sprayed	1	45.	3.5			
		2	34 5	8.	39.2	8.6	47.8
		3	38.	14.5			
II	Sprayed twice	4	73.5	9.5			
		5	44.	7.	60.5	8.5	69.0
		6	64.	9.			
III	Not sprayed	7	50.	13.	50.	13.	63.
IV	Sprayed twice	8	74.	10.			
		9	64.	15.5	69.2	11.2	80.4
		10	69 5	8.			
V	Not sprayed	11	35.	13.			
		12	34.	7.	36.3	9.3	45.6
		13	40.	8.			
VI	Sprayed twice	14	70.	13.5			
		15	74.	10.	72.		
		16	79.	12.		12.1	84.1
		17	65.	13.			
VII	Not sprayed	18	33.	2.5			
		19	23.	4.5	31.6	3.8	35.4
		20	39.	4.5			
VIII	Sprayed three times	21	72.	4.5			
		22	67.	0.5	70.6	2.6	73.2
		23	73.	3.0			

The final averages per row including all of above data are:

Not sprayed ....Sound 37.2; rotten 7.8, total 45. percent rotten 17.4
Sprayed twice ....Sound 67.7; rotten 10.7, total 78.4, percent rotten 13.7
Sprayed three times...Sound 70.6; rotten 2.6, total 73.2, percent rotten 3.6

The rows were three feet apart and fifty-five feet long so that each row represents 1-264 of an acre. The yields of sound potatoes per acre as shown in the above experiment are, where not sprayed, 164 bushels per acre, where sprayed twice, 298 bushels per acre, where sprayed three times, 311 bushels per acre. The gain was, therefore,

134 bushels where sprayed twice, and 147 bushels where sprayed three times.

Discussion of Results.—Little is to be added to what has been stated heretofore. Bordeaux mixture again proved a reliable remedy in a trying season. The twice sprayed rows appeared almost as green as those sprayed three times. More rot occurred in these twice sprayed rows than the condition of the tops led us to expect. The loss was probably in part due to the fact that the two earlier sprayings were made by unskilled farm laborers who gave less attention than our trained assistants usually have to spraying the lower leaves. The fungus therefore had an opportunity to develop sufficiently on these to cause considerable rot, except where the third and more careful spraying was made on plot VII. On the face of the above returns there would seem to be a considerable profit from the third application. As a matter of fact we believe that if the second had been made as thoroughly on the lower leaves as was the third it would have sufficed to prevent the rot that occurred. For these reasons and because the figures for the two sprayings represent more reliable averages than for the three and are more directly comparable with the unsprayed plots we have chosen them for insertions in the table below. This table gives in summarized form some of the results obtained during twelve years past which in our judgment are fairly representative.

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES.

Variety	Planted	Sprayed	Yield per acre		Gain per acre
			Where sprayed	Where not sprayed	
White Star..	May 11, 1891..	Aug. 26, Sept. 8.......	313 bu.	248 bu.	65 bu.
" " ..	May 20, 1892..	July 30, Aug. 13, 25....	291 bu.	99 bu.	192 bu.
" " ..	May 20, 1893..	Aug. 1, 16, 29.........	338 bu.	114 bu.	224 bu.
" " ..	Apr. 26, 1894..	June 16, July 17, Aug. 30	328 bu.	251 bu.	72 bu.
" " ..	May 20, 1895..	July 25, Aug. 13, 31...	389 bu.	219 bu.	170 bu.
Polaris........	May 15, 1896..	Aug. 7, 21.............	325 bu.	257 bu.	68 bu.
"	June 1, 1897..	July 27, Aug. 17, 28.	151 bu.	80 bu.	71 bu.
White Star..	May 10, 1898..	July 21, Aug. 10.......	238 bu.	112 bu.	126 bu.
Average 3 yrs	May 18, 1899..	July 26, Aug. 17, Sept. 8	229 bu.	161 bu.	68 bu.
Delaware....	May 23, 1900..	Aug. 4, 23.............	285 bu.	225 bu.	60 bu.
"	May 25, 1901..	July 20, Aug. 21.......	170 bu.	54 bu.	68 bu.
"	May 15, 1902..	Aug. 1, 20.............	298 bu.	164 bu.	134 bu.
Averages for twelve years....................			280 bu.	165 bu.	115 bu.

RESULTS FROM SPRAYING THE SOIL.

There are various causes for the rotting of potatoes. The common one in Vermont is the invasion of the tuber by the same fungus (*Phytophthora*) which causes the late blight or "rust" of the leaves. The popular idea of those who have observed this association of the blight and the rot is that the fungus causing the disease passes down the stem, but De Bary advocated some forty years ago that the decay of the tuber results chiefly if not wholly from the spores which fall from the leaves to the soil, and this explanation has been accepted by the later botanists generally.

While carrying on our spraying experiments this summer it occurred to us to try the effect of spraying the soil underneath the plants in certain unsprayed rows where the blight was developing. It seemed probable that if the rot of the tubers results from spores falling upon the soil, such spraying would reduce the amount. Accordingly early in August nine rows were set apart for this trial. The soil was a gravelly loam, fairly well drained, variety Delaware, planted May 15. The plants had not been sprayed up to this time, and there was a sprinkling of blight evident on the foliage of many of them, and as the results show the spraying was delayed too late for the full protection of any of the plants.

They were divided into three plots of three rows each which were treated as follows:

Plot I. August 13, the branches of the plants were raised and the spray directed underneath so as to wet the surface of the soil while avoiding the foliage as far as possible.

Plot II. Not sprayed in any way.

Plot lIII. Sprayed the tops as usual with bordeaux mixture on August 13 and on September 6.

As a result the blight was checked on plot III where the foliage was sprayed whereas it continued to develop in plot I where the ground alone was sprayed. By the first of September the foliage of the Plots I and II was practically all dead whereas that on plot III continued alive well through that month. When dug the second week of October the yields were as follows in pounds per row:

PLOT I. GROUND SPRAYED

Row	Sound	Rotten
1	45	0
2	60	1
3	46	1.5
Total,	151	2.5

PLOT II. NOT SPRAYED

Row	Sound	Rotten
4	45	3.5
5	35	8
6	38	14.5
Total,	113	26.

PLOT III. VINES SPRAYED

Row	Sound	Rotten
7	74	9.5
8	44	7.
9	64	9.
Total,	182	25.5

The gradual increase of rot progressing from rows 1 to 6 coupled with the irregularities in yield indicates that there was an unforeseen variation in soil conditions which favored the rot more on one side than on the other of the piece. The above results are not to be interpreted as final therefore; but, so far as they show anything, it is that spraying the surface of the soil greatly reduced the amount of rot. This result is in harmony with the idea that the tuber infection results from spores passing through the soil and which may be destroyed by such spraying. This method of spraying is not advocated as a practical remedy.

III. RELATION OF DATE OF DIGGING TO DEVELOPMENT OF ROT

How soon after the tops begin to blight should the potatoes be dug? This question has been asked so frequently that it was planned to secure some evidence regarding the matter this season. The following which appeared in a leading agricultural paper[1] some weeks after the work was begun shows that the investigation was timely: "Whether or not farmers shall dig their potatoes early to prevent rot is a question on which the search light of science has not been sufficiently turned. The best potato growers are divided in their opinion in the matter and experiment station workers are able to give but little advise based upon actual research."

To obtain some facts bearing upon this question experimentally, diggings have been made in a number of fields at different dates and the amount of rot noted at such times as well as that which subsequently developed. Fields which had not been sprayed were plainly desirable for such an investigation and also such as represented various conditions of soil and of disease. Since all of the plants on the Experiment farm had been sprayed permission was secured from a number of

[1] N. E. Homestead, Sept. 27, 1902, p. 291.

farmers in South Burlington to use portions of their fields for the trial diggings.

On August 23rd rows two and one-half rods long were staked off on the several farms, a part of which were to be dug on each of the following dates: August 25th, September 6th, 18th, and 30th. Following is a description of the plots, the condition of the tops on August 23rd, and each subsequent date till the tops were entirely dead.

Dewell's: Soil, sandy loam, neither very dry or moist. Ten rows, variety Enormous. Stalks and about ten percent of leaves green. Tops all dead on September 6th.

Wilson's (South Plot): Soil, clay loam. Six rows, variety Beauty of Beauties. Planted about June 1st. Showed blight on all hills, but leaves here and there only, so that field still looked green. September 6th, leaves all dead but stalks green. September 18th, tops entirely dead.

Wilson's (North Plot): Soil, like south plot, but somewhat more sandy. Nine rows. (Row three was not complete and was left out of the experiment.) Variety unknown. Planted last of May. Leaves dead with blight but stalks still green. September 6th, tops entirely dead.

Bixby's: Soil, sandy, well drained. Slopes south. Eight rows in pasture. Early variety, name unknown. Planted about May 1st. September 6th, tops entirely dead.

Holt's (South Plot): Soil, moist clay loam. Four rows, Beauty of Hebron, planted last of May. Early stages of blight, looked green but plenty of spots were found on the leaves. September 6th, leaves dead but stalks still green. September 18th, tops entirely dead.

Holt's (North Plot): Soil, very heavy clay loam, slopes to south. Eight rows, variety unknown. Planted early in June. Looked fairly green, but examination showed some blight scattered through. September 6th, considerably blighted, 25-50 percent of leaves green. September 18th, tops all dead.

With the exception of the rows dug on August 25th, the potatoes were allowed to stand over night in bags and then were poured into bushel boxes which were stacked up so as to allow free ventilation and kept in a cellar at a temperature of about 60° F. Every twelve days they were carefully sorted and all decayed tubers removed. Those dug August 25th remained in bags for the first twelve days at a temperature of from 65° to 70° F., considerably warmer than the average cellar. This may account for the relatively large percent of decay in this lot. On September 6th, they were placed in boxes and treated the same as the others.

The following tables give the total weights of each row when dug, the amount of decay at each sorting, the total decay, and the final weight of sound tubers on September 30th.

	Date of digging	Total weight	Pounds decayed Aug. 25	Pounds decayed Sept. 6	Pounds decayed Sept. 18	Pounds decayed Sept. 30	Average per row decayed to Sept. 30	Average per row sound on Sept. 30
Dewell's								
Row 1	Aug. 25	16.5	0	0	0	0.9	2.	14.7
" 5	" 25	16.9	0	.3	1.2	1.6		
" 2	Sept. 6	14	--	0	0	0	0.8	13.
" 6	" 6	13.6	--	.8	0	.8		
" 3	" 18	20.6	--	--	0	.4	0.4	15.8
" 7	" 18	15	--		0	.7		
" 8	" 18	13	--	..	0	0		
" 4	" 30	17.8	--	--	--	0	0.5	16.6
" 9	" 30	17.9	--	--	--	.4		
10	" 30	15.5	--	--	--	1.		
Wilson's (South Plot)								
Row 3	Aug. 25	8	0	4.4	.4	.2	5.	3.
" 4	Sept. 6	12.4	--	.8	.8	.7	2.3	10.1
" 2	" 18	11	--	--	.5	1.4	1.4	11.4
" 5	" 18	14.5	--	--	.5	.4		
" 1	" 30	13.5	--	--	--	.5	0.6	11.8
" 6	" 30	11.1	--	..	-	.6		
Wilson's (North Plot)								
Row 1	Aug. 25	39.3	0	11.7	13.3	.7	18.7	21.2
" 5	" 25	40.5	0	2.3	6.4	3.		
" 2	Sept. 6	29	--	1.4	.3	5.	4.3	26.2
" 6	" 6	32	..	.3	0	5.		
" 4	" 18	30.5	—	--	1.5	.3	1.2	34.3
" 7	" 18	40.5	—	--	.5	.1		
" 8	" 30	40.2	--	--	--	.5	0.9	34.4
" 9	" 30	30.2	--	..	--	1.2		
Bixby's								
Row 1	Aug. 25	54	0	.7	6.3	2.3	5.3	45.3
" 5	" 25	47	0	0	.5	.7		
" 2	Sept. 6	55.3	--	.5	.8	2.3	2.7	45.1
" 6	" 6	40.3	--	.2	.1	1.5		
" 3	" 18	48.4	--	--	--	--	0.	46.1
" 7	" 18	43.7	--	--	--	--		
" 4	" 30	46.5	--	--	--	--	0.	44.5
" 8	" 30	42.5	--	--	--	--		
Holt's (South Plot)								
Row 2	Aug. 25	19.3	--	7.2	3.3	1.9	12.4	6.9
" 3	Sept. 6	15.4	--	3.8	1.8	4.1	9.7	5.7
" 1	" 18	26.5	--	--	3.	1.4	4.4	22.1
" 4	" 30	15	--	--	--	4.5	4.5	10.5
Holt's (North Plot)								
Row 1	Aug. 25	25.1	0	5.1	6.	1.9	16.7	5.8
" 5	" 25	24.8	0	10.5	9.	0.8		
" 2	Sept. 6	23.1	..	7.2	0.9	4.	12.7	12.3
" 6	" 6	26.9	--	8.3	0.2	4.8		
" 3	" 18	24.6	--	--	6.6	3.5	9.3	14.5
" 7	" 18	23.0	--	--	5.5	3.		
" 4	" 30	19.7	--	--	--	5.2	7.4	17.3
" 8	" 30	29.5	--	--	--	9.5		

The following averages drawn from the above table will aid in the comprehension of the results:

Average total weight obtained per row at each date of digging:

When dug	Aug. 25.	Sept. 6.	Sept. 18.	Sept. 30.
Weight, pounds	28.6	26.2	25.9	24.9

Average weight of potatoes from each digging which were sound on September 30th:

When dug	Aug. 25.	Sept. 6.	Sept. 18.	Sept. 30.
Weight, pounds	18.7	20.9	23.5	23.0

Average decay per row on and previous to September 30th:

When dug	Aug. 25.	Sept. 6.	Sept. 18.	Sept. 30.
Pounds decayed	10.0	5.3	2.4	1.9
Percent decayed	35	20	9	8

Discussion of the results.—The size of the plots and the extent of the experiment are too limited to permit of sweeping generalizations. The temperature of the storage cellar was warmer than desired during the first two weeks and the results might have been different had it been cooler throughout the period. The results show wide variation on different soils and this suggests that on still other plots and in other seasons new combinations of conditions might occur to make the outcome different. Nevertheless it is clear that in no case did the amount of rot where the potatoes were left in the soil until the later date average greater than that where they were dug earlier; in some cases it was much less. These figures as they stand are liable to lead to an overestimate of the gain, however, since the actual amount of rot in the later dug plots is not clearly shown. When the potatoes were dug on the two later dates there were evidences that some tubers had almost or quite completely disappeared because of the rapid progress of the rot, and in many cases the partially rotten potatoes as sorted out at these later diggings had already lost much of their original weight. This fact accounts for the progressive falling off shown above in the average weight per row at each date of digging. It is clear, therefore, that the figures given under the last heading above, "average decay per row on and previous to September 30th," are too low for all except the first date. It would be more nearly correct to assume that the average weight of August 25th is the correct one to use as a starting point for each subsequent date and that the difference between that and the total weight actually found represents the weight of the tubers entirely lost by decay. Calculating in this way we secure the following:

Average decay per row on and previous to September 30th (computed).

	Aug. 25.	Sept. 6.	Sept. 18.	Sept. 30.
Pounds	10.0	7.7	5.1	5.6
Percent	35	27	18	19

The figures of greater practical interest and which are most easily understood, however, are those which show the returns of sound potatoes on September 30th. The same general conclusion is reached, whichever set of figures is taken, namely, that there was a greater loss on the average from the earlier digging.

Looking into the details more closely, however, it is seen that this was not equally great in all cases. Dewel's and Bixby's potatoes were grown on the lightest soil and died first. These show no noteworthy differences in rot, whether in cellar or field, after September. Wilson's potatoes grew on a somewhat heavier soil, the plants lived a little longer and the leaf blight was more in evidence. There this state of equilibrium was not reached until after the middle of September. At Holt's, where the soil was heavy, the plants lived longer and the leaf blight was worst, and it was apparently advantageous to delay the digging until the last of September. As nearly as we can formulate a rule based upon these results, it is that *where there is danger of rot it is best to delay the digging some ten days or more after the tops die and that a longer delay does no harm.* As stated before the experience of other seasons and on other soils is needed for safe generalizations.

If this is so, why is it? The question is pertinent but the attempt at a final answer may also well await further trials. The suggestion is made, however, that the rapidity of the invasion of the tubers by the fungus which causes the decay is accelerated as a result of the earlier digging either by the rise of temperature in the storage room or by some alteration in the physiological processes within the tuber. It may be conjectured that in the majority of cases where the tubers remain undisturbed in the soil the rapid invasion by the fungus ceases before it causes the death of the tissues of the potato tuber and that the fungus thereafter remains in a semi-dormant condition through the winter. Such a conjecture seems the more probable since a rapid decay of the tuber is doubtless destructive to the fungus as well as to the potato and so is disadvantageous to the former.

IV. THE EFFECT OF TOP PRUNING POTATOES

The moist cool weather of July and early August, 1902, led to unusual luxuriance in the development of potato tops especially where they had been properly sprayed. This condition brought to the Experiment station inquiries as to whether it was not desirable to check this tendency to vegetative vigor in some way as, for example, by breaking down the plants with a roller or by cutting them back. We have always advised against any such practice on theoretical grounds

but decided to put it to test this year since an especially favorable opportunity was presented through the courtesy of a local gardener, Mr. George W. Gero. His potatoes were the Green Mountain variety, planted May 19th on a rich sandy loam. They were well cared for, sprayed with bordeaux mixture July 23d and August 5th, and at the latter date showed an almost perfect stand of plants, completely covering the ground. Some neighbors of longer experience advised Mr. Gero to cut the vines back, else, it was said, "they would all run to tops" and he would lose much of his possible yield. He came to the station for advice and, while we discouraged him from mutilating his plants otherwise, we arranged to cut back the tops experimentally in a portion of the field. This was done on August 12th. The stalks were then about three feet long when straightened out and arose about two feet above the soil. They were cut clean at a height of one foot above the soil, which removed the bulk of the foliage. These stalks sent out within a few days many new shoots but this new growth began to yellow in about a week and the plants were dead by September first. In striking contrast the unclipped plants on either side were in full and vigorous foliage at this date and continued green through September; indeed there were some green plants when they were dug the second week in October. Seven rows, each one hundred feet long and three and one-half feet apart, were handled experimentally, five unclipped and two clipped. The yields were as follows:

Row 1,	not clipped,	yield 228	pounds.
Row 2,	not clipped,	yield 221	pounds.
Row 3,	clipped,	yield 150	pounds.
Row 4,	not clipped,	yield 223	pounds.
Row 5,	not clipped,	yield 224	pounds.
Row 6,	clipped,	yield 155	pounds.
Row 7,	not clipped,	yield 211	pounds.

Averages.—Not clipped, 221 pounds; clipped, 152 pounds.

It is evident that practically one-third of the crop was sacrificed by the clipping. This represents the result of but one trial and one method, but we believe that any other method which destroys or weakens any part of the green leaves of the potato plant in the latter part of the summer will proportionately decrease the yield. The popular notion to the contrary which is so frequently met is not so far as we learn based on careful experiments but is rather vague and theoretical. It seems to arise in part from a lack of appreciation of the importance to the plant of the green leaf and in part from a confusion of the physiology of tuber production in the potato with that of the fruit and seed production in tomatoes or similar plants.

V. POTATO SCAB EXPERIMENTS OF 1901 AND 1902

THE SUSCEPTIBILITY OF DIFFERENT VARIETIES OF POTATOES TO SCAB

One piece of land, a heavy clay loam, on the Experiment farm, has been used so frequently for potato culture during the last decade that the soil has become filled with the scab germ. A portion of this soil was used in trial plots in 1899 and in 1900 and the tubers were scabbed badly both seasons, in spite of the use of sulphur and other disinfectants.[1] It offered a favorable opportunity, therefore, to test the resistent powers of sundry varieties of potato to the scab fungus.

EXPERIMENTS OF 1901

In 1901 seed was secured of eleven varieties as follows: Carmen No. 1, Carmen No. 2, Crown Jewel, Delaware, Enormous, Green Mountain, Mammoth Gem, Nathan, New Queen, Sir Walter Raleigh, Uncle Sam. The seed was all free from scab spots, but the Delaware alone had been disinfected with formalin solution. The planting was done June 12, about four inches deep, digging October 22. Immediately after harvesting the tubers were examined and graded as to scab and it was found that practically every tuber of all varieties were more or less scabby. Any attempt to express their relative condition by figures would therefore be misleading.

Judging by the degree of scabbiness shown, two varieties, New Queen and Sir Walter Raleigh were more resistant than any of the others; Delaware and Carmen No. 1 stood next these in resistance; Uncle Sam and Green Mountain were most badly scabbed.

The resistance was in no case sufficient however to permit of profitable cultures of any of these on soil so conducive to the disease as that where this trial was conducted.

EXPERIMENTS OF 1902

In 1902 another trial was made on the same soil. The seed was all disinfected with formalin solution, the planting was done June 11, the digging on October 11. Fourteen varieties[2] were used. The name, position in the field and relative amount of scab of each is shown in the following table. Those marked "clean" had no scab spots, the "good" had one, two or three spots of scab, but as a whole would pass in the market as of good quality, while the "scabby" varied from tubers with several spots to those entirely covered with scab.

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[1]Vt. Sta. Rpt. 13, p. 278 (1900).

[1] The seed was secured as follows: Nos. 3, 4, 5, 14, from A. E. Manum, Bristol, Vt.; Nos. 1, 2, 12, 13, from E. L. Cleveland, Houlton, Me.; Nos. 6, 9, 10, 11, from H. F. Smith, Waterbury Center, Vt.; No. 7 from W. E. Johnson, Richmond Corners, Me.; No. 8 from Jones & Isham, Burlington, Vt.

In sorting it was noticed that the clean and good grades were more often the smaller potatoes which set late in the season, and in one or two cases none of these were large enough for table purposes. For this reason it appeared best to figure the percent clean and good on the basis of weight rather than of the number of the tubers, and this has been done in the following tabular summary of the results.

Number	Name	Total wt.	Scabby		Good			Clean		
			Wt.	No.	Wt.	No.	%	Wt.	No.	%
1	Green Mountain	66.5	56.3	265	10.2	85	15.3	3.5	45	5.2
2	Red Bliss	84.	78.3	499	5.7	90	6.7	1 6	37	1.9
3	Manu 's Seedling 11	31.5	26.3	144	5.2	50	16.5	1.7	24	5.3
4	Sir Walter Raleigh	66.	50.	256	16.	121	24.2	5.1	53	7.7
5	Enormous	87.5	64.7	231	16.8	74	19.2	4.8	38	5.4
6	Pingree	33.5	30.2	221	3.3	35	9.8	1.2	13	3.5
7	Pat's Choice	34.5	30.	198	4.5	52	13.0	1.5	19	4.3
8	New Queen	54.	51.	342	3.	45	5.5	1.5	26	2.7
9	Early Strawberry	79.	74.	694	5.	81	6.3	1.8	36	2.2
10	Joseph	34.	32.7	146	1.3	16	3.8	0	0	
11	Polaris	19.5	18.2	130	1.3	23	6.6	0.5	13	2.5
12	Beauty of Hebron	13.	13.	59	0	0		0	0	
13	Dakota	15.5	14.1	66	1.4	9	9.0	0	0	
14	Manum's Seedling 56	27.	15.5	47	11.5	41	42.5	4.5	19	16.6

Discussion of the results.—The varieties showing the greater degree of resistence to the scab in 1902 as indicated by the percents of "good" and "clean" tubers stand in the following order: Manum's Seedling 56, Sir Walter Raleigh, Enormous, Manum's Seedling 11, Green Mountain, Pat's Choice. It is worthy of note that the first four of these are from seed furnished by one potato breeder, Mr. Manum. Manum's Seedling 56 made an exceptionally good showing with almost 50 percent of merchantable tubers in striking contrast with the variety in the next row, Dakota, of which not a single tuber was free from scab.

A comparison of the results of the two seasons shows a considerable difference in the behavior of some varieties. Thus New Queen made a good showing in 1901 and a rather poor one in 1902, whereas the exact reverse is true of Green Mountain. Sir Walter Raleigh has a good record for resistance during both seasons.

The results are such at least as to lead to the hope that scab resistant varieties or strains may be secured by breeding and selection.

DISINFECTION OF SEED POTATOES FOR SCAB

The experiments of 1902 along this line were in continuation of those of 1901 and previous years. The plots were located as heretofore on recently cleared sandy soil not previously used for cultivated crops so far as known. Presumably it was free from scab germs.

The seed used in this experiment consisted of two varieties, Delaware and Rural New Yorker No. 2, selected from the crop from the scab plots of 1901. Those classed as "scabby" varied from tubers with one or two spots to those badly infested. On the average they would be classed as badly scabbed and unmarketable. The tubers of the Rural New Yorker were, on the whole, more scabby than the Delawares. Those classed as "smooth," while they came from the same plots as the scabby ones, showed no signs of scab. It is supposed that these would have the scab spores on them but to make this more certain they were rubbed with the scabby potatoes and some of the skin of the badly infested ones was scraped off and allowed to fall on them before they were disinfected.

The plantings were made in four long rows and the field was divided into five experimental plots according to treatment. Each plot contained one row of scabby and one row of smooth seed of each of the two varieties mentioned. Between the plots were check rows twenty feet long of another variety which had been thoroughly disinfected with formalin solution. The cultivation of all the rows was made in the same direction so that if any of the soil was carried from one plot to another the conditions would be uniform.

Treatment—For each plot one peck of scabby and one peck of smooth tubers of each of the two varieties was used and in all cases disinfection was performed within forty-eight hours before planting. Merck's formalin was used for plots I, III and IV.

Plot I. Formalin solution, 8 ounces in 15 gallons of water; soaked two hours in this solution.

Plot II. Corrosive sublimate solution, 10 ounces in 8 gallons of water; soaked 1½ hours.

Plot III. Formaldehyde vapor. In this treatment the tubers were first well soaked in water about half an hour and the many particles of dirt on the very scabby seed were carefully washed off with a brush. They were then placed while wet in a copper lined box upon open slat work shelves so that the vapor could easily come in contact with all sides of the potatoes. The scabby seeds were placed upon the lower and the smooth upon the upper shelf, and all openings in the box carefully sealed. The vapor was introduced through a hole in the bottom.

Novy[1] recommends for disinfecting hospitals and similar rooms, a distillation of 150 c. c. (5 ounces) of 40 percent formaldehyde to 1,000 cubic feet of space, in other words 0.15 c. c. for each cubic foot. At this rate, since the box contained only 8.2 cubic feet, 1.23 c. c. of formaldehyde would be required. Inasmuch as this amount was considered too small to be handled practically, and since it was believed

[1] Novy, F. G., Lab. Work in Bact., p. 529 (1899).

that a much larger amount could be used without injuring the seed, about ten times as much or 12 c. c. of formaldehyde was used.

The liquid was placed in a tightly corked glass flask from which a rubber tube extended to the interior of the box. Heat was then applied and the vapor distilled off as fast as possible. Unfortunately the flask broke before the liquid was entirely vaporized consequently not quite all the amount of liquid was distilled into the box. The box was kept tightly closed for twelve hours and when opened the odor of the gas was very strong.

Plot IV. Formaldehyde vapor and sulphur fumes. In this case the seed was first treated exactly as in the preceding lot (3) except that, before the formaldehyde vapor was introduced, a quantity of sulphur, 3 pounds to the 1,000 cubic foot, was placed in the box which was immediately closed. Again the flask broke just before the distillation of the formaldehyde was completed. At the end of twelve hours the odor of formaldehyde was as strong as in the first case but the sulphur had failed to burn. The box was allowed to remain open until the odor of the gas had practically disappeared. More sulphur was then introduced which burned completely, the seed being enclosed with these fumes for twelve hours.

Plot V. Untreated. In this case the seed was selected so as to be as nearly as possible like the plots I-IV but no disinfectant was used.

The planting was done April 25-28. There was no evidence of injury to the seed as shown by retarded germination in any case except plot IV, and in that it was not serious. The plants were cut back twice by the frost in the spring but recovered and made a good growth until killed by frost the first week of September. The tubers were dug and sorted about the middle of the month. The results are shown in the following table:

Plot number and variety	Condition of seed	Treatment	Smooth			Scabby			Tubers having more than two scab spots		
			Total wt.	Wt.	No.	Wt.	No.	%	No.	%	Aver'ge of each plot
Plot I.											
Delaware	Scabby	Formalin Sol....	136.0	127.6	1080	8.4	72	6.2	27	2.3	
"	Smooth	" "	137.0	135.8	852	1.2	8	0.9	2	0.2	
R. N. Y.—2	"	" "	131.6	127.6	873	4.0	27	3.0	13	1.4	
"	Scabby	" "	125.5	112.4	708	13.1	68	8.7	28	3.6	1.91
Plot II.											
Delaware	Scabby	Cor. Sub. Sol....	152.4	140.3	936	12.1	56	5.6	32	3.2	
"	Smooth	" " "	163.9	163.3	1080	0.6	4	0.3	0		
R. N. Y.—2	"	" " "	130 8	129.1	791	1.7	9	1.1	2	0.2	
"	Scabby	" " "	132.5	108.6	812	23.9	148	15.4	86	8.9	3.11
Plot III.											
Delaware	Scabby	Formalin vapor..	104.2	93.3	661	10.9	64	8.8	26	3.5	
"	Smooth	" " ..	125 0	106.6	833	18 4	100	10.7	60	6.4	
R. N. Y.—2	"	" " ..	143.3	138.6	940	4.7	26	2.6	8	0.8	
"	Scabby	" " ..	145.0	140.9	753	4.1	17	2.2	5	0.6	2.88
Plot IV.											
Delaware	Scabby	For. gas-sulphur	103.9	91.3	675	12.6	59	8.0	25	3.4	
"	Smooth	" " "	113.3	89.0	732	24.3	130	15.0	72	8.3	
R. N. Y.—2	"	" " "	132.5	114.7	744	17.8	88	10.5	49	5.8	
"	Scabby	" " "	125.8	120.2	769	5.6	32	3.9	8	0.9	4.66
Plot V.											
Delaware	Scabby	Untreated	118.4	81.2	543	37.2	277	33.7	176	21.4	
"	Smooth	"	124.2	111.5	828	12.7	87	9.5	43	4.6	
R. N. Y.—2	"	"	160.7	124.6	918	36.1	226	19.7	144	12.5	
"	Scabby	"	142.6	65.2	553	77.4	638	53.5	436	36.6	18.84

Discussion of results.—As in all previous trials both corrosive sublimate and formalin solutions have proved about equally efficient. We have settled upon the use of formalin for our regular field operations because of its non-poisonous character and greater convenience.[1] The present experiments were to continue the trials of gaseous disinfectants. In the tests of the last two years[2] sulphur fumes and formalin vapor and gas have not proved as satisfactory as have the standard solutions of corrosive sublimate or formalin. In these former trials the tubers were dry when subjected to the gaseous treatments and the formaldehyde gas was generated by evaporating the dry tablets. This year the seed potatoes were *wet* when placed in the disinfecting box, it being hoped that the gas action would thereby be rendered more energetic; and the formaldehyde gas was generated by vaporization. Some of the details of the results in the above table are hard to explain. The combined gases were apparently less effective than was

[1] For a general account of potato scab and practical directions for disinfecting the seed, see bulletin 85 of this station.
[2] Vt. Sta. Rpt. 13, p 273 (1900), and 14, p 23! (1901).

the formalin alone. The greater percent of scab in both plots III and IV was found in the rows where smooth seed was used. The easiest explanation of both these matters is that there was contamination by the cultivator in the passage from the plot V. The outcome is satisfactory, however, as indicating that fumigation of the moistened tubers with formaldehyde vapor greatly reduced the scab. While we are not ready as yet to recommend this method as a substitute for that of soaking the seed we do feel hopeful that further trials will develop some satisfactory method along these lines.

ORCHARD DISEASES AND THEIR REMEDIES

I. SCABBING AND RUSSETING OF APPLES IN 1902

The apple scab fungus developed more destructively upon the foliage and the young fruit in the early part of the present summer, 1902, than we have heretofore known it to do. Owing to the excessive amount of rainfall, spraying was much interfered with or altogether prevented. In some cases where applications of bordeaux-paris-green mixture was made in early June a rusting or russeting of the fruit was evident in July, and in a few cases there was a spotting of the foliage which must be attributed to the spray.

About this time complaints of similar troubles were so general in other Eastern states and in Canada as to show that there was some common cause of wide occurrence. Beach and Stewart of the New York State station have made a special study of the conditions in that state and since they are like those encountered in Vermont, we quote in part from their statements.[1]

"After a careful examination of many orchards we have reached the conclusion that the trouble is due primarily to weather conditions and is aggravated by spraying. The protracted cold, wet weather in June made the foliage tender and susceptible to injury from the spraying liquids. Some unsprayed orchards show a little of the trouble, but sprayed orchards are almost invariably the most affected. However, some sprayed orchards are but slightly affected. In general, cultivated and well-cared-for orchards are less affected than uncultivated and neglected ones, but there are some exceptions to this rule. While spraying under the existing weather conditions is the principal cause, it appears that several other factors enter into the problem and modify the results. Injury has resulted from paris-green with bordeaux, "green arsenoid" with bordeaux, "disparene" (or arsenate of lead) with bordeaux, arsenate of lime with bordeaux, and an arsenical insecticide

[1] Rural New Yorker XLI, p. 532 (1902)

with bordeaux. It is clear, therefore, that each of the common insecticides has produced injury. Whether bordeaux alone is capable of doing it has not been determined. In the territory examined by us serious injury is not likely to result except, perhaps, in a few of the worst affected orchards. In the majority of cases the slight injury done by spraying is likely to be overbalanced by the good done. Notwithstanding the loss of foliage in sprayed orchards it is likely that where thorough and seasonable spraying has been done the fruit will be superior to unsprayed fruit; whereas, in unsprayed orchards the damage to fruit and foliage from scab and codling moth may be expected to increase. It would be unwise to forget the great benefits of spraying in the past and to denounce or abandon it because of the unfavorable experiences of this season."

A visit to the orchards of Grand Isle the present autumn gave abundant evidence of the gain from spraying. Although there was a very serious amount of damage from the russeting, the quality of the well sprayed fruit averaged much higher than did that of the unsprayed. The experience of this seasons suggests, however, that the strength of the mixture should be more freely varied to suit the period of growth, the climatic conditions, and the fineness of the spray thrown by the nozzle. The coarser the spray the weaker should be the mixture; in the early spring a stronger mixture may be used than in summer; in cold wet weather like that of last May and June the mixture must be made weaker or applied with a finer nozzle than in a warmer, dryer season. For the strongest mixture we would recommend six pounds of copper sulphate and four pounds of lime to forty gallons of water, and for the weakest mixture for use in orchards, two pounds of each sulphate and lime to forty gallons; probably four pounds of each sulphate and lime to forty gallons is the best average amount. We would strongly urge that the attention to orchard spraying be not lessened as a result of the condition of the past season.

II. STUDIES UPON PLUM BLIGHT[1]

In August 1901 the station horticulturist reported that a peculiar blight was developing in the experimental plum orchard. In appearance the disease closely resembled the "twig-blight" of pears and apples, and he suggested that it was possibly due to the same organism. The investigation of the matter was placed in charge of Mr. L. P. Sprague, then laboratory assistant in botany, and now of the Rhode

[1] This article is published entire in Centralblatt f. Bakteriologie, 2 Abt., IX Bd. (1902). Since the journal has not reached us when this copy leaves our hands, we cannot cite the page.

Island station. The following account is based largely on his results,[1] and to him is due the credit for the details of the work.

Occurrence.—The variety upon which the blight was first observed was Cheney (*Prunus Americana nigra*, on Americana stock). These trees were located in a row about ninety feet north of a badly blighting row of pear trees. The plum trees were four years old, growing in a well fertilized clay soil which had been kept moist by the frequent rains prevailing during the spring of 1901; and as a result, the trees had thrown out many vigorous young shoots to which the blight was confined. Similar conditions have existed during 1902 and the blight again developed in midsummer, being most conspicuous during August, although its inception evidently occurred earlier. All the branches from which the organism was isolated both years were of the Americana group; but the station horticulturist, who has observed the distribution of blighted twigs in the orchard both summers, states that it has seemed equally prevalent on various members of the Hortulana group. He concludes that its distribution has been determined rather by the location in the orchard in proximity to blighting pear trees than by the relative susceptibility of varieties.

Appearance.—Numerous young shoots scattered over each tree were blackened and apparently killed for from six to eighteen inches back from the tip, the general appearance closely resembling that of the twig-blight on neighboring pear and apple trees. The bark on these shoots was dark brown above, but this blended below into the normal color of the healthy twig. Several twigs were observed in which the appearance of blight was confined to the zones girdling each of several nodes, indicating that the inception of the disease occurred at or near the nodes and almost simultaneously at several places along the branch. On many of the shoots, but not on all, cracks had opened in the epidermal covering exposing a dry or nearly dry gummy matter. Upon cutting into the diseased twigs small pockets of nearly dry gummy matter were occasionally found. The diseased shoots near the tip were drying, while below they were still moist and flexible. The leaves were

[1] We were led to give more careful attention to this blight than its economic importance as shown in the present outbreak would seem to warrant, because the occurrence of a similar trouble has been reported to us on previous occasions and in other orchards. Moreover a serious outbreak of what seems to have been the same malady is reported by Sturgis, (Conn. [State] Sta. Rpt. 18, p. 117 [1894]). The disease is there described as destructively prevalent in a large plum orchard. Bacteria were found in the blighting branches and were thought to be responsible for the trouble, but they were not isolated and the matter was left for further study. It seemed that we ought to attempt to settle the question if possible when so favorable an opportunity was presented.

Since the completion of our studies we learn from Dr. E. F. Smith of the U. S. Department of Agriculture, that the pear blight organism has also been isolated from plums by Waite.

brown and dead as far back as the discoloration of the bark extended and, in the longer standing cases, had already fallen from the tip of the shoot. The inner bark in the lower and, hence, more recently blighted portions, was discolored—brownish—but still moist. Microscopic examination of this moist inner cortical tissue, just above the place where the diseased blended with the healthy bark, revealed myriads of bacteria, and the gummy masses were found to be filled with similar organisms. These organisms agreed in size and appearance with those from pure culture of the pear blight organism, *Bacillus amylovorus*. After careful removal of the outer portions with a flamed knife, bits of this discolored inner tissue were taken from the point where the discoloration was just beginning to show, including the cambium layer and the outer wood, and were used in making poured plates.

Several such plates have been poured at different times during the summers of 1901 and 1902, and by three different persons, L. P. Sprague, H. D. Bone and the writer. In every case the result has been an abundant development of white colonies, all of which, so far as tested, have proved to be the pear blight organism. To permit of comparison, plates were poured at the same time and in the same way from blighting pear twigs and the results obtained were like those from plum. As a quick method of testing the organisms thus isolated, inoculations were made into green pear fruits in August or early September, using Bartlett in the earlier part of the season and an unknown variety of small winter pear later. The method is substantially that suggested to us by Waite of the Department of Agriculture. The end was cut from the pear with a recently flamed knife and a needle stab inoculation of the organisms made into the exposed flesh near the core. The results were in all cases alike with the suspected organisms, whether secured from the plum or the pear, viz: in about 48 hours at room temperature, 20°-22° C, the exudation of pearly or opalescent, bead-like viscid drops, dotting the cut surface of the inoculated fruit, often some distance, 0.5 c. m. or more from the point of inoculation. These droplets were teeming with bacteria and microscopic and cultural examinations confirmed the conclusion that the organism was the pear blight bacillus. These droplets slowly enlarged in size until they merged together forming large drops, half covering the cut surface of the fruit and the general death and decay of the tissues soon resulted.

Numerous tests were also made by the method of direct inoculation into these green pear fruits of bits of the blighting stem-tissues from plum and pear, also with the gummy exudate from the blighted plum twigs. The result in practically all cases was the prompt develop-

ment of the opalescent beads teeming with organisms which appeared to be identical, whether plum or pear tissues were used for the initial inoculations. To place the matter beyond possible doubt, however, careful cultural studies were undertaken by Mr. Sprague, who carried the two strains of organisms—one obtained from blighting pear, the other from blighting plum—through parallel series of cultures extending over eight months time and including a variety of media and leading to still more conclusive inoculation experiments. In every detail the behavior of the two strains was identical.

Inasmuch as there has been no record of the behavior of this organism upon many of the culture media tested, and since the facts observed were in some respects different from those given in Chester's description,[1] it seems worth while to give the following brief summary of the morphological and cultural characters observed. In all cases the methods and media employed were, unless otherwise stated, like those used in the studies of *Bacillus carotovorus*, discussed in the thirteenth report of this station, p. 314. The cultures were grown at approximately 30°C.

MORPHOLOGICAL CHARACTERS

Form.—A bacillus; usually single or in pairs, sometimes chains of threes and fours in young cultures.

Size.—(In microns) Young broth cultures, 0.9 to 1.5 long by 0.7 to 1 wide; longer (up to nearly 3) and slightly narrower in older broth cultures.

Grouping.—Slight tendency to pellicle formation and numerous small zoogloea masses in broth cultures.

Staining.—Stains readily with usual watery or alcoholic solutions, also by Gram's method.

Capsule.—None observed.

Flagella and motility.—Fairly motile in young cultures, less so in old ones. Flagella stains (Lowits' method, from 24-hour agar slants) not satisfactorily made but showed several peripheral flagella apparently 4-8 microns long; also structures doubtfully considered giant whips, 14 to 34 microns long.

Spores.—None demonstrated.

PHYSIOLOGICAL CHARACTERS

Nutrient broth.—Good growth; clouding perceptible in 8 hours, increasing to third day but never heavy as compared with *B. carotovorus*, *B. coli-communis*, etc.; pellicle and rim slight; moderate amount of gray-white deposit.

[1] Chester, F. D. Manual of Determinative Bacteriology, p. 176 (1901).

Gelatin.—Plate; buried colonies spherical, granular; surface colonies white, margins entire; *tube:* slow crateriform liquefaction confined to upper layers.

Agar.—Plate: buried colonies white, spindle-shape or spherical, granular; surface colonies white, circular, elevated, wet-shining, margins irregular; *stab:* growth along entire length; *slant:* white, wet-shining streak, thin along middle, heavier along sides, margins wavy, spreading in a few days over surface of slant.

Carbohydrate-agars: more rapid growth induced by additions of 2% of cane or of grape sugar or of maltose or of 5% of glycerine. No gas in shaken tubes of plain agar or in above named carbohydrate agars.

Milk.—Coagulation in 3 to 4 days, followed soon by gradual digestion to a pasty condition with separation of supernatant whey, no color. (Above is usual course but in some cases digestion set in before coagulation was complete, in others digestion was slower.)

Blood serum.—Growth similar to agar. No liquefaction.

Dunham's solution.—Rapid growth but clouding not dense, no pellicle or rim or zoogloea masses and deposit slight.

Cooked vegetables.—Slanted cylinders partially immersed in water; potato, carrot, beet, turnip. Good growth in all, best in beet, weakest in turnip. In all alike a wet-shining white streak along line of inoculation; liquid heavily clouded, white and nearly opaque. Tissues not softened, no odor, gas or pigment.

Temperature relations.—Optimum 25-30° C; no growth at 0.5° C (broth); very slow growth at 3° C. Recently inoculated broth tubes were rendered sterile by 10 minutes immersion in thermal bath at 43.7° C and similar exposure at 43° C retarded growth.

Oxygen relations.—Facultative anaerobe. Slight growth in closed branch of fermentation tubes, and in tubes sealed immediately after inoculation; very slight in oxygen-free atmosphere (Buchner method); slight in hydrogen; no appreciable growth in carbon dioxide.

Acid and alkali production.—There is a slight excess of acid development in most media during the first few days (e. g. milk, broth). but this is soon overcome by a predominence of alkali production. (Litmus milk: color bleached before perceptible reddening. Rosolic acid peptone solution faded but original color returned after two weeks. Milk cultures titrated against phenolpthalein as follows: Before inoculation 2.1%; 5th day, 3.0%; 8th day, 2.6%, 17th day, 1.4%.)

In the presence of certain carbohydrates there was a predominence of acid development. Thus broth cultures tested with litmus paper

reacted as follows: all before inoculation being alike distinctly alkaline to litmus (neutral to phenolpthalein):

Plain broth: Progressive slight decrease of alkalinity during first week, at no time reaching point of acid reaction, then gradual return to alkalinity during second and third weeks to original reaction at end of month thereafter remaining constant.

Broth+2% saccharose.—Progressive loss of alkalinity during first three days, neutral on fourth, progressive increase of acidity until on the fourteenth day it was distinctly acid.

Broth+2% glucose.—Acid development slightly slower than in cane sugar but the condition the same on the fourteenth day.

Broth+2% lactose.—Little if any change in reaction during two weeks.

Reduction processes.—Nitrate-broth showed no development of nitrates. Litmus milk and rosolic acid peptone-water both showed progressive bleaching during the first week (less rapid than *B. carotovorus*); during the second week color slowly returned, reaching original condition at end of fourth week.

Indol.—Considerable produced (less than *B. coli-communis* but more than *B. carotovorus*).

Hydrogen sulphid.—None detected from broth cultures.

Odor.—No characteristic odor perceived from any culture.

Desiccation.—Drying on cover-glasses, at about 20° C, for various periods up to 5 days had no appreciable effect; 16 days caused slight retardation in development; 76 days was fatal.

Insolation.—Ten minutes exposure of freshly poured agar plates to March sunlight retarded development somewhat; 30 minutes was fatal.

Gas production.—None in shaken tubes of carbohydrate agars (see agars); none in fermentation tubes containing broths with 2% of either glucose, saccharose, lactose, or glycerine.

Pigment.—None; growth white or grayish-white on all media used.

INOCULATION EXPERIMENTS

These have included numerous repetitions of the inoculations into green pears (one-half to three-fourths grown) following the method previously described and practically always with like results. The fruit in these cases was placed in a closed chamber at 20°-22° C. Inoculations were also made at two different times with a pure culture of each strain (from plum and from pear) by needle stabs into immature Bartlett pears which were left clinging to the parent tree. In every such case the inoculations led to similar results, namely, the death and browning of the tissues, accompanied by the exudation of numerous white viscid bead-like droplets upon the surface first about the point

of inoculation, and, later, over the entire surface. The blight thus started usually invaded the fruit spurs and in some cases girdled the parent branch.

Inoculations made into detached pear fruits approaching maturity gave less prompt and characteristic development than with the younger fruits and greater liability to contamination.

Inoculations with pure cultures made in the same way into sectioned, detached, unripe plums, led to a development similar to that on the pears, as evidenced by the exudation on the cut surface of beaded drops teeming with the organisms. These drops were, however, less milky in color than those from the pears, indicating a less vigorous development of the bacillus. As the plums approached maturity such inoculations were not uniformly successful. Stab inoculations into seven unripe plum fruits, left clinging to the tree, led, in three cases, to the death and decay of the fruits, which was apparently caused by the development of the organisms inoculated; but in none of these cases did the disease extend into the twig.

A second series of inoculations into the plum fruits as they were approaching maturity led to no development or decay.

Numerous inoculation experiments were undertaken in September, using pure cultures of both strains, into young (first year) shoots of plum and pear in the orchard. These included some sixty inoculations into as many different twigs, some of the wounds being covered with sterile grafting wax, and some with moistened paper and cloth. In no case was there any signs of infection or blight as a result.

During the winter seedling plums were grown in the green house. When these were a few inches high, in February and March, inoculations were made by needle punctures near the tip into 18 plants, agar cultures being used, including both strains of organisms. None of these caused blight. These inoculations were twice repeated with the same negative results.

At the same time seedlings and cuttings of pears were started. Only one of the seedlings grew. This was inoculated (about March 1) by needle puncture near the tip of the stem from an agar culture of the plum blight strain of the organism. Blight developed promptly so that at the end of five days the stem was blackened from the point of inoculation to its apex and, also, nearly to the base, and the discoloration was invading the petioles and bases of the leaves. At this juncture a poured plate was made from the interior tissue of one of these blackening leaf bases, the original organism found in abundance and recovered in pure culture.

The only plants available for further inoculation tests in pear at this time were cuttings made in the autumn and started in sand. These

were now well clothed with young shoots and six of them were selected for the trial. A needle prick inoculation from a young agar culture was made into the base of each of three of the young shoots of each stem. Of the 18 shoots thus inoculated 9 (on 3 stems) were from cultures taken from the plate obtained from the blighting leaf just mentioned above, 6 (on 2 stems) were from the original plum strain of the organism and 3 (on 1 stem) were from the pear strain. Every shoot inoculated developed the characteristic blight within three days from the date of inoculation, and, at the end of a week, every such young shoot was dead and the blight was spreading both up and down from the base of the shoot as shown by the discoloration and sinking of the bark. The characteristic viscid, opalescent drops of exudate, were found in places upon all, teeming with the organisms. In some cases it was so abundant as to coalesce and run down the stem, or, upon partial drying, to gum the leaves together or to the side of the stem. In all cases the behavior was similar and typical of pear blight.

It was planned that the inoculation experiments should continue farther and include a repetition of those upon pear and plum twigs in the orchard in the spring and early summer. Mr. Sprague, however, having been appointed assistant horticulturist at the Rhode Island Station, removed from the state and was unable to carry on the work; nor was it practicable that the trials could at this time be further prosecuted.

In conclusion we may briefly summarize the results of the inoculation experiments as follows:

The two strains of organisms, from plum and from pear, behaved alike in all cases.

Inoculation into unripe pear, either with bits of diseased bark or of pure cultures, led alike to characteristic growths. Ripening lessened susceptibility of the fruit.

Inoculations into sections of unripe plum led to growth only under favorable conditions. Inoculations into ripening fruit failed altogether.

Inoculations into plum branches were in no case successful.

Inoculations into pear shoots failed when they were in a semi-dormant condition (September), but led to rapid blighting when vigorous growth was occurring.

It is seen at once that these results fail of complete solution of the problem undertaken, in that successful inoculation of plum branches was not accomplished, although they leave no doubt it our mind that the pear blight bacillus is the cause of the plum blight. It is shown conclusively that the plum is much more resistant to the invasion of the blight organism than is the pear, and infection, probably, is pos-

sible only when conditions are peculiarly favorable during spring and early summer—a season of the year when no inoculations were attempted.

THE CULTIVATION OF THE LOCUST TREE [1]

There are small areas of sterile sandy soil scattered through Vermont, especially in the northern Champlain and southern Connecticut valleys, which are not profitable for ordinary agricultural purposes. These were originally covered with forest growth probably consisting largely of the pitch pine (*Pinus rigida.*) Owing to its natural adaptation to this soil and to its abundant seed production, this species has taken almost complete possession of the dryer of these soils where they have been abandoned to second growth of trees. This pine is the least valuable of the evergreens. If these lands are to be given over to sylviculture it is a question whether it is not worth while to have the ground occupied by something better. The moister and less sterile of the sandy soils are, of course, admirably suited to white pine, and certainly where this develops naturally it is the most profitable tree to grow.

The University owns a tract of the most barren type on the sand plains east of Burlington. The entire area was, until recently, covered with pitch pine, but this was cut clean between the years 1892 and 1896. This method of harvesting the crop was perhaps not the wisest with reference to its reproduction. The soil is so dry and the seed trees of any kind left are so few that another crop of trees has been very slow in starting. It has seemed worth while to do some experimental planting on this area and this has been done in the spring of each of the years 1897, 1898 and 1902. The species used in these trial plantings have included white pine, Norway spruce, European larch, red oak, chestnut, white birch, cottonwood, box-elder and the common locust. Most of these trees have not stood long enough to justify any detailed report. Suffice it to say that the two that now promise best returns are the white pine and the locust. The question of white pine cultivation is one of great importance in sections of the Champlain and Connecticut valleys, but we are not prepared to contribute anything to it at present other than its general commendation. The experiments with the locusts, however, have progressed sufficiently far to justify a

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[1] The tree referred to (*Robinia Pseudacacia, L.*) is commonly planted about farm houses throughout Vermont and is popularly known simply as the locust; sometimes, however, the names yellow and black locust are used. It has in many places spread along the roadsides, occasionally forming dense thickets. It is not a native of Vermont, being found wild only from Pennsylvania south and west.

preliminary report, inasmuch as the outcome is already so promising as to lead us to suggest that trial plantings of this tree ought to be made by such as possess suitable soils.

RECORDS OF OUR PLANTATION

One hundred seedling trees, height about 12 inches, were bought in 1897 and set in rows four feet apart each way. These were planted rather late in the spring and, probably owing to this fact and to the sterility of the soil, only 57 of them have survived. Numerous sprouts have come up from the roots so as in a measure to make up for the number that have died. The young locusts have made a remarkable growth, far outstripping any other trees in the plantation. In the spring of 1902[1] they averaged ten feet in height and over two inches in diameter at the base, some being nearly three inches. Practically all of this growth has been made during five years. That their development will probably continue at a similarly rapid rate is shown by measurements made upon seedling trees growing spontaneously upon similar soil nearby in the same field. These are 11 years old, 16 feet high and 5 inches in diameter at the base.

On similar but somewhat cooler and moister soil, of a northerly slope,there is a roadside thicket of locust trees of various ages from which the following data has been obtained. The trees make a uniformly rapid growth for thirty or more years, averaging, during this time, an increase in diameter at the base of nearly one-half inch each year. Thus of two typical young trees each 19 years old in this thicket, one was 8 inches, the other 10 inches in diameter one foot above the ground.

LOCUST ROOTLETS
Showing nitrogen-gathering nodules

[1] For these measurements we are indebted to Mr. L. E. Grout, who, as a student in the Agricultural Department of the University, made "The Reforestation of the Sand Plains" the subject of his senior thesis investigation.

Both of these, growing as they were in a crowded grove, had pushed up straight and tall and possessed fully twenty-four feet of clean trunk which is sufficient for three fence-post lengths. These figures show a rate of growth rather below than above those usually given for the locust and they are probably somewhat less than occurs in richer soils. An explanation of the relatively rapid growth of this tree in sterile sandy soil lies in the fact that it belongs to the legume family and, like the clovers, peas, etc., acquires its nitrogen from the air.

From the data given it seems probable that twenty years from the setting the trees upon this sand plain plantation many of them will be from 8 to 10 inches in diameter at the base and will therefore make good posts. It will doubtless pay, however, to cut some for stakes earlier than this, in order to thin them and then, at the end of the twenty years, to cut only the largest ones, allowing the others to stand a few years longer.

Encouraged by this small trial planting, 5,000 more seedling trees 12 to 18 inches in height were bought and set out early in April, 1902. Ninety-two percent of these trees are alive and making a rapid growth at the end of this first summer and there is no doubt that these are all well enough established now to be beyond further danger. The station farm superintendent has had charge of the fitting of the ground and the planting of these trees. He estimates the expense as from $20 to $25 per acre. To this must be added the cost of the trees, $3.50 per thousand, 2,560 trees per acre, which is $7.68. It has been our practice to plant potatoes between the trees and cultivate them for the first year or two, and this crop has more than repaid the expenditure for fertilizer and for the cultivation.

THE VALUE OF THE CROP

Locust timber is used for numerous purposes including posts of various kinds, telephone and other poles, ship-building, pins and railroad ties. It probably has greater value for fence posts than for anything else in this locality. Locust posts, as is well known, will outlast any other kind used in Vermont unless it be the red cedar. If well seasoned before setting, a locust post will stand from 30 to 60 years. It is worthy of note in this connection that the slower grown wood from dry sandy soil, like that under discussion, makes the most lasting and, hence, the most valuable posts. Locust posts are rarely quoted in our markets but a reliable dealer informs us that he could afford to give more for them than for similar sized white cedar posts. A recent writer in "Forestry and Irrigation" (A. Neilson, August, 1902) places the value of board-fence posts at 20 cents and wire-fence posts at 10

cents each. One can from the data at hand estimate the return from the locust plantation although such estimates can rarely take into full account the various sources of expense or loss unless they are based on previous experience. We have planted 2,560 trees to the acre. Assuming that the value of poles cut during their development will pay for the work of pruning and thinning and that one-fourth of the trees are standing and suitable for posts at or about the twentieth year, there will then be 640 trees to the acre, each of which may be expected to yield two board-fence posts and one wire-fence post. Estimating these at 15 and 10 cents respectively gives a valuation of 40 cents a tree or $256.00 an acre. The expense of cutting must be deducted from this but there will be the value of a considerable amount of fuel to be added. It would seem, therefore, that a very profitable crop is assured after making all reasonable allowances. The greatest element of uncertainty is the danger from borers, which is discussed later. They have as yet done little damage but may become more serious.

In view of the increasing demand for and the decreasing supply of posts it would seem a wise investment for many farmers to start at least a large enough locust plantation to supply the posts needed on the place, and some might find that several acres given to locust culture would be profitable.

SUGGESTIONS FOR PLANTING[1]

The trees are easily started from seed planting one-half inch deep in light garden soil; or the seedlings can be bought very cheaply from nurserymen as was done in the present case for $3.50 per thousand.

After the locust is once established it will continue to reproduce itself by coppice growth, since it sprouts vigorously from the stumps and roots following each cutting. This second growth pushes up more rapidly than the seedling plants and presumably, therefore, will be the less liable to trouble from borers. In the roadside thicket from which we obtained some of our data such second growth sprouts three years old were from one and one-half to two and one-half inches in diameter at the base. There will be no cost for renewed planting, therefore, and a second crop of posts can probably be cut in from 12 to 18 years after the first is removed.

MIXED PLANTATIONS

The chief element of uncertainty in the cultivation of the locust is, as has already been suggested, the danger from borers. At

[1] The seed may be planted as soon as collected. If kept dry for any length of time it should be soaked for a day in warm water before planting. It is said that one pound of seed is sufficient to sow in a nursery row 900 feet long.

times, especially farther west, these pests so riddle the trunks of the young trees as to greatly lessen their value and, in some cases, actually to kill the trees. Serious damage from these insects is usually confined to the young trees which are lacking in vigor. In order to lessen this danger efforts should be directed to keeping the trees in thrifty growth for the first dozen years. It is also stated that the best growth and, hence, lessened trouble from borers results when they are mixed in plantations with heavier foliaged trees. The explanation of this is that the locust alone does not form dense enough shade to keep down the grass, weeds and other undergrowth. For this purpose the catalpa and mulberry are recommended farther south since they cast a heavy shade and do not grow fast enough to overtop the locust. Since neither of these two species is well adapted to our climate, we have made trial plantings of a number of other kinds of trees. The desideratum is a heavy foliaged tree that will not overtop in its growth the locust and which will of itself be of value. The white and pitch pines, elm, canoe birch, black cherry and box-elder are all claimants for favor. We are inclined to choose the white pine, however. In order to force the young trees into the straight tall growth which is essential, thick planting is necessary. In most cases 4 by 4 or 3 by 6 feet is recommended. It is said that it is sufficient to plant every third row with the shade giving species in mixture, that is, with the white pine or some similar tree.

KILLING WEEDS IN LAWNS

Since our earlier publication relative to the successful use of salt in killing the orange hawkweed, or paint brush,[1] and of copper sulphate in destroying "kale" in oat fields,[2] we have received numerous requests for like specific remedies for various other specific weed troubles. In most cases it has been necessary to reply that none was known; but the repeated questions from so many sources have shown the need of more exact information along these lines. The use of herbicides is bound to increase in the near future just as that of insecticides and fungicides has done in recent years. There are many caustic and poisonous byproducts of sundry industries which are fatal to plant life, of low cost and of great abundance. These will increasingly replace the expensive hand labor now so generally used in hoeing out roadside gutters, scraping tennis courts and raking gravel walks. We have been led, therefore, to continue experimental trials of herbicides.

Attention has been this year directed to some of the more common and troublesome lawn weeds. Apparently most of the coarser, deep-

[1] Vt. Sta. Bul. 56 (1896).
[2] Vt. Sta. Rpt. 13 (1900), p. 284.

rooted perennials can best be combated by frequent spudding or cutting out and close mowing accompanied by proper fertilization, watering and abundant seeding with the proper lawn grass at favorable seasons. Dandelions, plantains, white daisies, and the docks are best dealt with in this way. These plants all have a distinct "crown" near the surface. A remedy used with some success against these pests consists of the application of a few drops of a strong acid to the center of this crown. Sulphuric acid may thus be applied with a glass tube. or crude carbolic acid with a common metal oil can. In most cases however, we believe spudding to be the better method.

There is another class of weeds which are very shallow-rooted and succeed even under close mowing because of their creeping habits or because of the abundant production of seed on prostrate stems. The orange hawkweed, or paint brush (*Hieracium aurantiacum*), smaller crab-grass (*Panicum lineare*) and common chickweed (*Stellaria media*) are three of the more troublesome of this class. The trials first reported in bulletin 56 of this station showed that salt, when properly applied, is a perfect remedy against the hawkweed. It has seemed worth while to try it, along with various different remedies and methods, against the other two weeds. The outcome in the case of the crab grass has not favored the use of salt but with the chickweed it has proved a very satisfactory herbicide as the following accounts will show.

CHICKWEED

These trials were made on a well fertilized and closely mowed lawn on a rather heavy clay soil, sloping gently to the east. The turf, where good, was mainly Kentucky blue-grass with some timothy, redtop, and white clover. In the areas chosen for trial the chickweed was so abundant from midsummer on as almost completely to overtop the grasses and clovers. Indeed the sensation on stepping on it was not unlike that afforded by a bed of sphagnum moss.

Plot	Date treated	Treatment given	Condition Sept., 1902
1.	Oct., 1901.	Heavy sowing of grass seed mixture without raking.	No appreciable benefit.
2.	Oct., 1901.	Thorough raking to tear out chickweed, followed by heavy seeding with grass mixture.	Some improvement, but not satisfactory.
3.	May, 1902.	Same as 2, but using redtop seed.	Unsatisfactory, though some improvement.
4.	May, 1902.	Same as 2, except that raking was done with extra thoroughness.	Fair stand of grass and not much chickweed.

5.	June 15, 1902.	Scattered dry salt at rate of 2 qts. per sq. rod; followed by raking and sowing seed mixture.	Lawn grass somewhat browned at first, now fully recovered and a good stand; all chickweed and white clover killed.
6.	June 25, 1902	Same as 5, except that seed was more thoroughly raked in.	Perfect success; no browning of grass; grass shows excellent stand; all chickweed and clover killed.
7.	June 25, 1902.	Same as 6, but no salt applied.	Condition good, but considerable chickweed remains; not equal to 6.

CHICKWEED

These trials are being continued but the results to date seem to justify the following:

Conclusions.—1. Treatment either by raking or by the sowing of salt or both combined were far more effective against chickweed when made the last week of June, than when made earlier in June, in May or in the late autumn. This was possibly in part due to the fact that the growth of chickweed was farther advanced and, doubtless, in part to the dryer and hotter weather prevailing then and immediately thereafter.

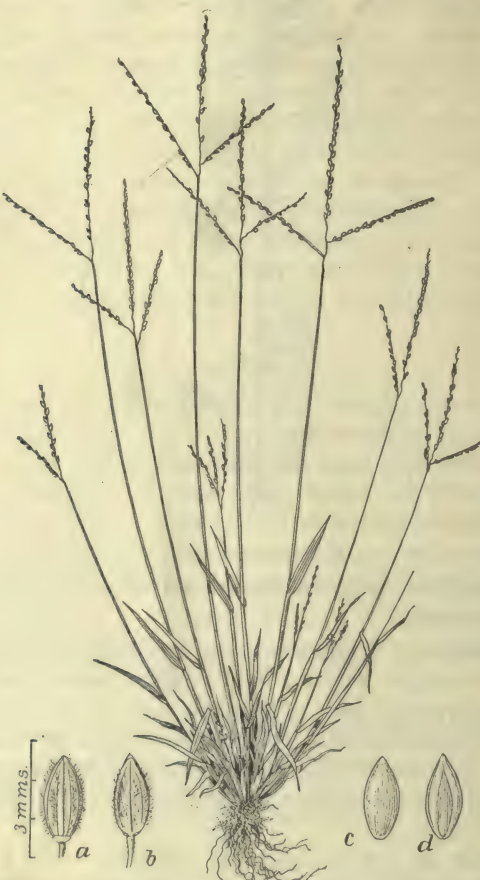
2. Tearing out the chickweed at this time (June 25) by a thorough raking followed by the raking in of an abundant seeding of grass, destroyed most but not all of the pest.

3. The application at a dry time (June 25) of two quarts of salt to the square rod, followed by the thorough raking out of the chickweed, and by a liberal sowing of grass seed well raked in, was completely successful in exterminating the chickweed and in securing a full stand of grass.

We suggest that any one employing salt on a lawn do so cautiously and on a small scale at first as the effects will doubtless vary somewhat with soil and season.

CRAB-GRASS

Plot 5 was the only one of the series referred to above, where crab grass was abundant. The treatment there given (dry salt, thorough



THE SMALLER CRAB-GRASS. (After Scribner, U. S. D. A.)

raking, sowing grass seed in the middle of June) was ineffective. This pest is so entirely different in its nature from chickweed that it is not to be expected that it can be controlled by the same method. To fight crab-grass successfully one should understand the following facts concerning it:

It is an annual grass, no roots living over winter. It forms an abundant crop of seeds on the spreading finger-like branches terminating the stems. These appear and ripen quickly from midsummer on, but most abundantly in late August and September. If the grass were not mowed, these would be erect or ascending, but under close cropping with the lawn mower they become practically horizontal and, lying prostrate in the lawn grass, they escape cutting and ripen their seed undisturbed. The plant grows best in a light, dry, warm, sandy soil and its seed does not germinate until the soil becomes thoroughly warmed up in June, indeed little is seen of it in the lawn until late in July. It is evident, therefore, that there is time to get a good stand of timothy and white clover started from seed sown in the autumn or early spring before this weed grass can germinate. This is especially true in a moist, cool season like the last one, and this condition can be favored any season by the use of fertilizers and the water sprinkler.

The specific methods we recommend to get this grass out of lawns and to keep it out, are as follows:

1. Be sure that none is introduced in the grass seed.

2. Use grass seed, fertilizer and water freely as needed to keep a full stand of grass in vigorous growth.

3. If but little of the crab-grass appears in the lawn, weed it out by hand.

4. If it occurs in considerable amount, in late summer and autumn rake the place where it occurs before using the lawn mower so as to raise the prostrate seed-stalks high enough to insure that they are all cut off. Repeat the raking and mowing frequently,—once a week or oftener, during the autumn, to prevent the maturing of seed so far as possible.

5. Remembering that this weed grass will die during the winter, make a heavy sowing of grass seed in early spring so that all bare spots in the lawn are promptly covered with a new growth in the early spring and the new seeding fully established before the crab-grass seed germinates in the early summer.

6. For such seeding use a mixture of timothy and Kentucky bluegrass with *much white clover*.[1] Ten pounds of timothy, ten pounds of

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[1] For more detailed account of methods of making and seeding lawns, see bulletin 94, on Vermont Grasses and Clovers.

blue-grass and two pounds of white clover is a well proportioned mixture for most soils; but in fighting this weed grass we have found it desirable to increase the relative amount of clover seed, especially on sandy soil. Be sure to keep the newly seeded lawn well watered.

7. In starting a new lawn aim to secure a soil for the surface layer which is free from the seeds of this pest. In seeding this do not depend on the "lawn grass mixtures" of the trade, but get the three varieties named above, avoiding the use of the coarser clovers (red and alsike), or the annual grasses(ray-grass,etc.), which occupy the ground but a short time and then, dying, leave vacant places to be invaded by weeds.

REPORT OF THE BOTANISTS

L. R. Jones and W. J. Morse

The general policy of the work in the botanical department remains unchanged. Plant diseases and their remedies continue to occupy the first place among the detailed investigations. At the same time an interest is maintained in other botanical problems that relate to agricultural science. Observations and experiments have accordingly been continued upon economic grasses and clovers and upon the weed plants of the state. Co-operative work has been undertaken with the United States Department of Agriculture along three lines of a considerable practical as well as scientific interest, namely, forestry, the cultivation of drug plants, and the inspection of grass and clover seeds.

The subjects which are in such condition as to justify detailed report upon them are as follows:

Occurrence of plant diseases in Vermont in 1903.

Potato diseases and their remedies.

- Results from spraying potatoes.
- Relation of date of digging to the development of rot.
- Does liming prevent rot?
- Potato scab experiments.

Notes on certain threatening weeds.

The shrubby cinquefoil as a weed.

OCCURRENCE OF PLANT DISEASES IN VERMONT IN 1903

WEATHER CONDITIONS

The summer of 1903 was an unusual one. From the middle of April to the first week of June there was no rainfall at Burlington and a similar condition of drought existed throughout the northeastern section of the country from Maine to the Potomac. This was followed by unusually copious rains and cool, cloudy weather during July and August. The effect of the weather conditions as regards pathological conditions of plants was shown in various ways. Most insect pests were less troublesome than usual. This was true, for example, of both the Colorado potato beetle and the flea beetle. The fungi which make their chief headway in the spring, such as apple scab, were also less troublesome than usual. On the other hand, certain physiological diseases were unusually prevalent as a result of the abnormal weather conditions.

POTATO BLIGHTS

Few potatoes made much growth until the rains came in June. They then developed with unusual rapidity. This vigorous growth coupled with the absence of insects already noted, gave a fine stand of tops by the middle of August. Less arsenical poisoning than usual was noted because less of paris green and similar insecticides were used. The late development of the plants, coupled with the climatic conditions, led to little tip burn. The early blight did little damage about Burlington up to September first, except on the light sandy soils. On such it was serious by August first and increased rapidly thereafter. The late blight fungus was also tardy in appearing, being fully three weeks later than last year. The first blighting leaves were found about August 10 in 1903. The malady spread gradually during August. Some pieces of potatoes on sandy soil escaped entirely, but practically every field about Burlington, other than these, was badly blighted before September first. The resultant rot was naturally general and severe.

Early sprayings with insecticides or fungicides alike profited less than usual. This outcome is in marked contrast with that of last year, when an unusually early application was needed. This will doubtless tend to discourage some who, through lack of experience, sprayed too late in 1902 and too early in 1903. It emphasizes again the importance of learning to recognize the maladies to be controlled. As shown in the discussion of the spraying experiments (page 157), a single thorough spraying given at the right time was a sufficient protection.

ORCHARD DISEASES

There was practically no loss from apple and pear scab even on the more susceptible varieties, such as Fameuse apples and Flemish beauty pears. This was true regardless of whether the trees were sprayed or not.

The weather conditions caused some russeting of the skin of apples. This was more evident on the sprayed than on the unsprayed fruit, although occurring on the latter. Frost bands were conspicuous upon apples in many parts of the state. This development of a band of russeted skin upon the otherwise smooth fruit is caused by a touch of frost just after the fruit set.[1] Such russeting of fruit, whether a result of climatic conditions or of spraying, injures neither its keeping quality nor its flavor.

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[1] See discussion of frost bands on apples and pears, Vt. Sta. Rpt. 9, p. 104 (1895).

The bacterial disease pear blight was also less prevalent than usual on pears, and no twig blight was observed on plum trees. The brown rot of plums also caused but little destruction.

GARDEN VEGETABLES

A soft rot of turnip developed badly in the station garden where several varieties were grown. This is a bacterial disease similar in cause and character to the bacterial soft rot of carrot. The organism which causes it is being studied at present at this Station.

Club rot of cabbage, turnips, etc., was reported from certain localities. It is apparently becoming widespread in the State. Onion mildew was again destructive in those sections where onions are grown as a field crop. The remedies for both these maladies have been discussed previously.[1]

POTATO DISEASES AND THEIR REMEDIES

I. THE RESULTS FROM SPRAYING POTATOES IN 1903

1. GAINS FROM USE OF BORDEAUX MIXTURE

Experimental sprayings of potatoes with fungicides and other compounds have been conducted at this Station each summer for fourteen years. During this time a large number of preparations have been tested and nothing equal to bordeaux-arsenical mixture has been found for use in the latter part of the season. The gains from the right use of this mixture have been large on the average and are chiefly attributable to the prolongation of the life of the foliage into the autumn, through protecting it from both fungus and insect ravages. In general two applications of the mixture have proved most profitable. Owing, however, to the late appearance of the blight in 1903, and the fact that its development was checked by continuous dry weather in early September, a single application of the mixture, about the tenth of August, proved sufficient for the preservation of most of the foliage from blight. On heavy soil there was some rot where the plants were sprayed only once, but the crop in the main field of the station farm, which was a sandy loam, three and one-half acres in extent, thus sprayed once, retained its foliage in good shape well through September and yielded over 1200 bushels of marketable potatoes with practically no rot.

No unsprayed rows were left in this field, but in a smaller one on higher but somewhat heavier soil, records were obtained. This field was planted with the Green Mountain variety about May first, and

[1] Vt. Sta. Rpt. 10, p. 61 (1897), mildew; Bul. 66 (1898), club root, etc.

given one thorough application of bordeaux mixture on August 10. As has been previously stated the late blight appeared comparatively late in the season and one application gave practical protection. The plots were dug September 24. The unsprayed tops had been dead for some two weeks, while at least fifty percent of the foliage was still alive on the sprayed tops. The sprayed and unsprayed portions were carefully selected with a view to uniformity. Each lot consisted of four rows fifty-eight feet long. The total yields calculated in bushels to the acre are as follows:

Sprayed, 392 bushels per acre;

Unsprayed, 285 bushels per acre;

This shows an increase in total yield as a result of spraying of 107 bushels per acre.

The records of the amount of decay in the sprayed and the unsprayed plots make the actual gains even greater.

Numbers of bushels per acre of sound tubers in unsprayed plots	361
Number of bushels per acre of decayed tubers in sprayed plots	31
Number of bushels per acre of sound tubers in unsprayed plots	237
Number of bushels per acre of decayed tubers in unsprayed plots	48
Percent of decay in sprayed plots	8
Percent of decay in unsprayed plots	17
Gain per acre of bushels of merchantable potatoes	124

DISCUSSION OF THE RESULTS

This gain was not as large as it has been in seasons when the blight has come earlier and progressed more rapidly. On the other hand under such conditions two or even three sprayings are required to preserve the foliage until the maturing of the crop. The *gain of 124 bushels per acre as the result of a single timely spraying* represents a larger gain in proportion to the cost than we have heretofore recorded. We learned of cases where potato growers sprayed their plants twice this season *in July* and secured but little benefit for the simple reason that by the time the blight was destructive, the latter half of August, their plants were unprotected. Our experience again serves to emphasize sharply the point we have repeatedly made, that *in order to spray most profitably a man must know what he is spraying for, watch his crop and spray intelligently as well as thoroughly.* To paraphrase the old saying, a spray in time saves the crop. *Timeliness* is an important factor in success. That it pays richly to use *thoughtfulness*, *thoroughness* and *timeliness* may be judged from the cumulative data showing the results from thirteen consecutive season's work at this Station. These figures speak for themselves.

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES.

Variety	Planted	Sprayed	Yield per acre		Gain per acre
			Where sprayed	Whe'e not sprayed	
White Star...	May 11, 1891.	Aug. 26, Sept. 8.........	313 bu.	248 bu.	65 bu.
" " ...	May 20, 1892.	July 30, Aug. 13, 25......	291 bu.	99 bu.	192 bu.
" " ...	May 20, 1893.	Aug. 1, 16, 29............	338 bu.	114 bu.	224 bu.
" " ...	Apr. 26, 1894.	June 16, July 17, Aug. 30	328 bu.	251 bu.	77 bu.
" " ...	May 20, 1895.	July 25, Aug. 13, 31......	389 bu.	219 bu.	170 bu.
Polaris........	May 15, 1896.	Aug. 7, 21................	325 bu.	257 bu.	68 bu.
"	June 1, 1897.	July 27, Aug. 17, 28......	151 bu.	80 bu.	71 bu.
White Star...	May 10, 1898.	July 21, Aug. 10.........	238 bu.	112 bu.	126 bu.
Average 3 var.	May 18, 1899.	July 26, Aug. 17, Sept. 8	229 bu.	161 bu.	68 bu.
Delaware	May 28, 1900.	Aug. 4, 23	285 bu.	225 bu.	60 bu.
"	May 25, 1901.	July 20, Aug. 21.........	170 bu.	54 bu.	116 bu.
"	May 15, 1902.	Aug. 1, 20................	298 bu.	164 bu.	134 bu.
Green Mount.	May 1, 1903.	Aug. 10..................	361 bu.	237 bu.	124 bu.
Averages for thirteen years.................			286 bu.	171 bu.	115 bu.

2. ADDITIONS OF BUG DEATH AND PARIS GREEN TO BORDEAUX MIXTURE

This experiment was conducted in a field belonging to the Mary Fletcher hospital. Its object was to determine the relative efficiencies of bug death and paris green when used alone and with bordeaux mixture in the latter part of the season.

The soil was a somewhat sandy loam, one which, as a general thing, produces large crops of potatoes in this vicinity if properly fertilized and if fungi and insects are kept off so that the plants are able to reach maturity. With the exception of a few depressed, slightly moist areas, the soil conditions of the field, consisting of about three acres, were quite uniform.

The plots selected were on a slight rise, and the plants over the entire area were uniform in size and condition on the first of August, when the experimental sprayings were begun. They had received one application of dry paris green about a month or more before, which had sufficed to keep them fairly free from the Colorado beetle, although the effects of this had disappeared. The foliage was entirely healthy, showing no early or late blight, and no paris green poisoning on the leaves. There were, however, quite a number of young and a few old Colorado beetles on each row. On July 20, twenty-four rows, each forty-five feet long, were staked out, and sub-divided into three plots of eight rows each. On August 3 these were treated as follows:

Rows 1, 9, 17, paris green in water.

Rows 2, 10, 18, check, untreated.

Rows 3, 11, 19, bordeaux-paris green mixture.

Rows 4, 12, 20, bordeaux-paris green mixture.

Rows 5, 13, 21, bordeaux-bug death mixture.

Rows 6, 14, 22, bordeaux-bug death mixture.

Rows 7, 15, 23, bug death applied dry.

Rows 8, 16, 24, bug death applied dry.

METHODS OF PREPARING AND APPLYING THE MATERIALS USED

Paris green.—One-half pound of paris green was used to forty gallons of water, and enough freshly slaked lime was added to give the mixture a decidedly white color. The paris green and the lime in the form of a thick whitewash were first mixed together and allowed to stand sometime before adding to the water.

Bordeaux-paris green mixture.—This was prepared according to the standard formula (6 lbs. copper sulphate, 4 lbs. fresh stone lime, 40 gallons water, ½ lb. paris green). The lime was slaked and diluted with one-half of the water, the copper sulphate dissolved in the other half and the two dilute solutions poured at the same time into a third vessel, the mixture being constantly stirred.

Bordeaux-bug death mixture.—This was prepared as recommended by the manufacturers of "bug death." The process is essentially the same as has been described above, except that bug death was added to the copper sulphate solution at the rate of twelve and one-half pounds to forty gallons of water before mixing with the dilute lime solution.

Bug death dry.—This was applied to the tops at the rate of fifty pounds per acre, by shaking through a cloth bag furnished by the manufacturers with the compound.

The liquid preparations were applied by means of a knapsack sprayer, care being taken to spray all the foliage thoroughly. Consequently the amount of bug death applied in the bordeaux-bug death mixture was over twice as much per acre as that where bug death was applied dry.

In six days, August 9, all the sprayed rows alike were free from the Colorado beetles, except for occasionally mature insects, whereas there were about as many on the check rows as there were at the time of spraying.

On August 16 there appeared to be very little change from the condition noted the week before.

The record on August 28 (nearly four weeks from spraying), was as follows:

Paris green in water: Yellowing with blight and insect injuries. (Row 9 better than 1 or 17.)

Untreated: Same as above. (Row 10 better than 2 or 18.)

Bordeaux-paris green: Excellent condition.

Bordeaux-bug death: Excellent condition.

Bug death applied dry: Considerable blight and yellowing of leaves.

Ten days later (September 7) the stalks were still green but the foliage was entirely dead on the check rows as well as on those rows treated with paris green, and bug death dry, with the exception of rows 23-24 (bug death), where about twenty-five percent of the leaves were still green. The remaining rows (bordeaux and insecticides) were still green, at least ninety percent of the leaves being healthy, though the effects of both early and late blight could be found on these rows.

A week later (September 14) the rows sprayed with bordeaux-paris green and bordeaux-bug death still showed from fifty to seventy-five percent green leaves. No great difference could be observed between them. The tops on the remaining rows were entirely dead.

The plots were dug on October 7th (two months after spraying), when the tops on all the rows were entirely dead, with an occasional exception where bordeaux mixture had been used. The following gives the treatment and the yield from each treatment (three rows), in pounds:

Treatment.	Yield, 3 rows.
Paris green	220 pounds.
Control (untreated)	241 "
Bordeaux-paris green mixture	278 "
Bordeaux-bug death mixture	280 "
Bug death applied dry	237 "

DISCUSSION OF THE RESULTS

The data displayed in the foregoing table correspond fairly well to the differences as judged from the appearance of the foliage before digging. It will be seen that the paris green, bug death and untreated rows average much alike. Owing to one row where soil conditions proved unfavorable the product of the paris green rows dropped below the others. Doubtless the fact that the untreated rows yielded slightly more than either the bug death or paris green is again due to slight inequalities in soil. The only conclusion which seems justified is that the climatic conditions of 1903 growing period were so unusual that there were very few insects on the potato plant and, hence, that neither of these insecticidal treatments was required nor did any appreciable good. Practically all of the damage in this field after the experimental spraying of early August, was due to the late blight of the foliage. This

is a fungus disease and neither paris green nor bug death are fungicides. The results of our trials of two years ago[1] showed that bug death, while it has value in checking insect ravages, was not effective as against the late blight. The results of the present trial are fully in accord with this observation.

It should be clearly stated, in justice to its manufacturers, that they do not advertise it as a fungicide. But many farmers fail to discriminate in this respect and think of this compound as of possible value in controlling the fungus diseases. The manufacturers advise that bug death be added to bordeaux mixture at the rate of from seven to fifteen pounds to the barrel (fifty gallons). Inasmuch as this is a heavy addition, making the cost for the bug death more than for the bordeaux mixture, it is important to decide whether the value of the combination is increased proportionally to its increased cost. We have always added paris green or similar arsenical poison to bordeaux mixture, even in the late summer. As a matter of fact, it is doubtful whether it is needed unless the insects are unusually prevalent. The amount of this poison used is so small in any case as to make the cost a trifling matter, and, since the presence of the lime in this mixture prevents any possibility of arsenical poisoning, we have continued its use in all cases.

It is evident from the figures, as it was from the foliage before digging, that both of these bordeaux compounds were entirely satisfactory and practically alike in their results. It is believed that the outcome would have been the same had simple bordeaux without any insecticide been used in lieu of bordeaux alone, since this wards off most insects. This seems the more probable in view of the fact that in the other series where no bordeaux was used, the results were practically alike. Of course benefits might have come from the addition of either paris green or bug death had insects proved serious.

The conclusions warranted by the results thus far discussed seem to be as follows:

(1) Neither paris green nor bug death used alone have value in checking the late blight, even where, in the case of bug death, very liberal application is made.

(2) So far as controlling late blight is concerned, bordeaux-bug death mixture and bordeaux-paris green mixture are both efficacious, the one as good as the other, and doubtless simple bordeaux mixture without any insecticide added would prove as good as either.

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[1] Vt. Sta. Rpt. 13, p. 271 (1900).

To avoid being misunderstood, we will repeat what we have stated in previous years,[1] that it is outside of the plans of these experiments to inquire closely into the insecticidal value of bug death. We have, however, seen evidence[1] that it has such value in trials of former years. This year in the absence of insects this factor did not enter into the results.

II. RELATIONS OF DATE OF DIGGING TO DEVELOPMENT OF ROT

"How soon after the tops begin to die from the late blight should the potatoes be dug?" This question is of much practical importance and we undertook in 1902 to secure an answer.[2] Although the results obtained in those trials appeared definite and justified a tentative deduction, it was felt that conditions might so vary from year to year that further trials were needed. Accordingly on August 31, twenty rows of potatoes, forty-five feet long, were staked off on a field belonging to the Mary Fletcher hospital. These were on rather low ground in slightly moist and somewhat sandy soil. The late blight was abundant over the entire field, although it had mostly developed within the preceding week. On the plot selected one-third to one-half of the foliage had been killed during this week by late blight.

Four rows were dug on each of five different dates, at intervals of one week, in such a manner as to give each time as near as possible an average of the plot. The following record shows the date of digging of each row and the condition of the tops at the time.

August 31. Rows 1, 6, 11, 16: foliage from one-third to one-half killed with late blight.

September 7. Rows 2, 7, 12, 17: leaves all dead but stalks green.

September 14. Rows 3, 8, 13, 18: stalks practically all dead.

September 21. Rows 4, 9, 14, 19: tops dead.

September 28. Rows 5, 10, 15, 20: tops dead.

Each lot was stored within a few hours after digging in a cool, house cellar, where the temperature was uniformly 55°-60° F. The tubers were placed in bushel boxes, stacked up so as to allow free ventilation. The yield from each row was divided into two equal parts, one of which was used in the liming experiments (pages 163-165), inasmuch as there was practically no difference in the amount of rot in the limed and unlimed potatoes dug at different dates (see pages 163 165), it is allowable to include the results attained with both the limed and the unlimed tubers in the present discussion.

[1] Vt. Sta. Rpt. 13, p. 271 (1900).

[2] Vt. Sta. Rpt. 15, p. 219 (1902).

When each lot was dug they were carefully sorted and the weight of decayed tubers recorded. Those in storage were sorted on each date of digging, beginning September 7 and ending September 28.

The following table shows the weight of the tubers from each row when dug, the amount of decay when dug, the amount of decay at each sorting and the final weight of sound tubers on September 28.

Row	Date of digging	Total weight	Pounds decayed Aug. 31	Pounds decayed Sept. 7	Pounds decayed Sept. 14	Pounds decayed Sept. 21	Pounds decayed Sept. 28	Total pounds decayed to Sept. 28	Total pounds sound on Sept. 28
1	Aug. 31	46.5	0.	0.	0.	6.5	0.	6.5	40.5
6	" "	44.5	1.5	1.0	9.2	19.6	2.0	34.3	10.2
11	" "	51.7	0.7	0.8	4.5	21.7	5.8	33.5	18.2
16	" "	60.0	1.0	1.0	5.4	20.4	9.9	37.7	22.3
2	Sept. 7	42.0		1.6	0.7	3.0	2.0	7.3	34.7
7	" "	62.5		2.5	0.4	7.4	6.7	17.0	45.5
12	" "	49.0		4.0	0.9	3.1	5.8	13.8	35.2
17	" "	66.0		1.0	0.6	9.0	7.6	18.2	47.8
3	Sept. 14	54.6			4.5	3.8	1.5	9.8	44.8
8	" "	56.7			2.4	1.5	0.5	4.4	52.3
13	" "	59.4			4.2	0.9	3.8	8.9	50.5
18	" "	49.6			6.6	0.7	5.0	12.3	37.3
4	Sept. 21	61.2				8.1	1.5	9.6	51.6
9*	" "	38.4				3.2	0.	3.2	35.2
14	" "	66.5				6.5	0.	6.5	60.0
19	" "	50.2				3.7	2.0	5.7	44.5
5	Sept. 28	52.5					7.0	7.0	45.5
10	" "	59.3					1.0	1.0	58.3
15	" "	44.0					4.5	4.5	39.5
20	" "	45.5					2.5	2.5	43.0

The results are more clearly set forth in the following averages taken from the above table.

The average total weight obtained per row at each digging:

When dug	Aug. 31	Sept. 7	Sept. 14	Sept. 21	Sept. 28
Weight, pounds	50.6	54.9	55.1	54.2	50.3

Average weight of potatoes from each digging which were sound on September 28:

Date of digging	Aug. 31	Sept. 7	Sept. 14	Sept. 21	Sept. 28
Weight, pounds	22.8	40.8	46.2	47.8	46.6

Average decay per row previous to September 28:

Date of digging	Aug. 31	Sept. 7	Sept. 14	Sept. 21	Sept. 28
Pounds decayed	28.0	14.1	8.7	6.2	3.7
Percent decayed	55.3	25.7	15.8	11.4	7.3

* The low yield was doubtless due to the fact that this row was extremely weedy.

DISCUSSION OF RESULTS

The results of this experiment are entirely in accord with those previously reported.[1] The work this year was confined to one field and one type of soil, but the quantity of tubers used was much larger than that taken from any one field last season. The conditions of storage were better, and probably much better than those in the average farm cellar.

Regardless of the percent of decay during any one period the most important question to be considered is which procedure will give the largest amount of sound tubers in the end. It will be seen that there is very little difference in the results from those dug September 14, 21 and 28, while the digging of September 7 gave about eight-ninths as much, and that of August 31 less than one-half that obtained from the three later dates. The death of a large percent of the foliage occurred between August 31 and September 7, and the entire tops were dead on September 14. Hence the data obtained this year appear to confirm the rule laid down in the former report: "*That where there is danger of rot it is best to delay the digging some ten days or more after the tops die and that a longer delay does no harm.*"[1]

III. DOES LIMING PREVENT ROT?

Many farmers recommend sprinkling potatoes with air-slaked lime when placed in the cellar. This treatment it is claimed reduces the amount of decay in stored tubers. In order to test the efficacy of this treatment, one-half of the yield of each row used in the trial last described (except those dug on September 28), was sprinkled at the rate of about a quarter of a pound of lime to the bushel and placed side by side with the unlimed portion. The nature of the soil, dates of digging and sorting, and condition of foliage at each digging, have already been described.

The following tables gives the detailed comparison of the amount of decay in each row, both limed and unlimed, on the dates of sorting, as well as the totals for each lot on September 28:

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[1] Vt. Sta. Rpt. 15, pp. 222-223 (1902).

Row (limed)	Row (untreated)	Date of digging	Weight of sound tubers when dug	Pounds decayed on Sept. 7		Pounds decayed on Sept. 14		Pounds decayed on Sept. 21		Pounds decayed on Sept. 28		Total pounds decayed Sept. 28	Total pounds decayed Sept. 28	Total pounds sound Sept. 28	Total pounds sound Sept. 28
				Limed	Untreated	Limed	Untreated	Limed	Untreated	Limed	Untreated	Limed	Untreated	Limed	Untreated
1		Aug. 31	23.2	0.		0.		2.9		0.					
	1	"	23.2		0.		0.		3.6		0.				
6		"	21.5	0.5		3.5		10.8		1.5					
	6	"	21.5		0.5		5.7		8.8		0.5				
11		"	25.5	0.6		2.8		8.1		4.8					
	11	"	25.5		0.2		1.7		13.6		1.0				
16		"	29.5	0.6		2.2		10.9		4.8					
	16	"	29.5		0.4		3.2		9.5		5.1				
												56.0	53.8	43.7	45.9
2		Sept. 7	20.2			0.7		1.5		1.0					
	2	"	20.2				0.		1.5		1.0				
7		"	30.0			0.3		2.7		3.7					
	7	"	30.0				0.1		4.7		3.0				
12		"	22.5			0.1		0.3		4.2					
	12	"	22.5				0.8		2.8		1.6				
17		"	32.5			0.6		3.8		6.1					
	17	"	32.5				0.		5.2		1.5				
												25.0	22.3	80.2	82.9
3		Sept. 14	25.0					1.6		0.					
	3	"	25.0						2.2		1.5				
8		"	27.1					0.7		0.5					
	8	"	27.1						0.8		0.				
13		"	27.6					0.2		2.0					
	13	"	27.6						0.7		1.8				
18		"	21.5					0.7		1.5					
	18	"	21.5						0.		3.5				
												7.2	9.0	94.0	92.2
4		Sept. 21	26.5							1.5					
	4	"	26.5								0.				
9		"	17.6							0.					
	9	"	17.6								0.				
14		"	30.0							0.					
	14	"	30.0								0.				
19		"	23.2							1.6					
	19	"	23.2								0.4				
												3.1	0.7	94.0	96.4

The following statement combines the results of all the four plots used in the experiment:

Total decay of limed potatoes to September 28..........	91.3
Total decay of untreated potatoes to September 28......	85.8
Total of limed potatoes sound, September 28	311.9
Total of untrated potatoes sound, September 28	317.4
Percent of decay in limed	29
Percent of decay in untreated	27

DISCUSSION OF RESULTS

So far as can be judged from the results of this single experiment there is nothing to be gained by liming, there being but two percent

difference and that in favor of the untreated tubers. Perhaps the most significant comparison can be made from the lot dug August 31, since in that the greatest amount of decay occurred. The unlimed showed nearly 54 percent decay from the date of digging to September 28, while the limed gave over 56 percent decay in the same period.

This trial of one season with only a few bushels of potatoes should not be regarded as conclusive. It does, however, lead us to doubt the value of the practice, the more so because on theoretical grounds we should expect that after the potatoes are in storage no further infection would occur. It is expected to repeat the trial when conditions again favor. Meanwhile the writer would be glad to learn of the experience of any potato growers with liming potatoes, where definite gains were demonstrated.

IV. POTATO SCAB EXPERIMENTS

Experiments in the disinfection of seed potatoes for scab were carried out during the season of 1903, along the lines suggested by the results of previous years. The plots were located on recently cleared pine land, not previously used for cultivated crops, and which, in all probability, was free from scab germs.

Two varieties of seed were used, Delaware and Rural New Yorker No. 2. This seed was selected from the crop grown on the scab plots of 1902. As in the past, two grades of seed were planted, "scabby" and "smooth." Taken as a whole the scabby tubers were so badly diseased as to be unmarketable. The smooth tubers did not show any visible signs of the disease, but they were sorted from the same lots as the scabby seed. Presumedly they carried the scab germs. To make this certain they were rubbed with scabby tubers, and some of the scabby growth was scraped off and sprinkled over the smooth seed.

The seed was planted in four long rows, and these were divided into five plots according to treatment. Between the plots were check rows twenty feet long of another variety which had been previously disinfected with formalin solution.

Treatment.—One peck of scabby and one peck of smooth seed of each of the two varieties was used in each plot. Before disinfecting, the seed tubers for plots II, III, IV and V were first washed to remove all clots of dirt. The bags in which the seed was placed after disinfecting were steamed for one hour under a steam pressure of fifteen pounds. All disinfecting was performed within twenty-four hours before planting. The tubers were treated thus:

Plot I. Formalin solution, 8 ounces in 15 gallons of water; soaked for two hours.

Plot II. Corrosive sublimate solution, 1 ounce[1] in 8 gallons of water; soaked for one and one-half hours.

Plot III. Formaldehyde vapor (seed wet). The washed potatoes were placed while still wet in a copper lined box on open slat shelves so that the vapor could easily come in contact with all sides of the potatoes as in 1902. The scabby seed was placed on the lower and the smooth seed on the upper shelf. The box contained 8.2 cubic feet of space; it was sealed air tight and contained a small hole near the bottom into which was fitted a pipe leading from the distillation apparatus. In 1902, 12 c. c. of formalin was used for distillation. Since no bad effects were noticeable in the germinating qualities of the potatoes thus treated, this amount was increased this season to 25 c. c. for each treatment, or at the rate of over 3000 c. c. (3 quarts) for each 1000 cubic feet of space. This is over twenty times as much as is recommended for disenfecting a sick room.[2]

The process of distillation was as follows: A small coil of one-half inch gas pipe was made and fitted with a removable cap at one end, while a piece of one-fourth inch gas pipe connected into the disinfecting box was attached by a reducing elbow to the other end. When ready for use the cap was removed, the formaldehyde was introduced into the coil and the cap screwed on, graphite being used to make all joints air tight. The coil was then placed on a large gas burner, the burner lighted and the formaldehyde vapor distilled into the box as rapidly as possible.

Plot IV. Formaldehyde vapor (seed dry). In this case the treatment was the same as with plot III, save that the seed was allowed to become thoroughly dry after being washed. The tubers were then placed in the box and disinfected as above.

Plot V. Untreated. The seed was washed to remove the clots of dirt but no disinfecting solution was used.

The following table shows the data obtained:

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[1] Through an error in our last report, this was made to read, "10 ounces in 8 gallons of water," instead of 1 ounce in 8 gallons of water. See Vt. Sta. Rpt. 15, p. 227 (1902).

[2] Vt. Sta. Rpt. 15, p. 227 (1902).

Plot number and variety	Condition of seed	Treatment	Total weight of tubers	Smooth		Scabby			Average per-cent of scabby potatoes on each plot
				Weight	Number	Weight	Number	Percent	
Plot I									
Delaware	Scabby	Formalin Sol...	138.0	134.9	924	3.1	21	2.2	
"	Smooth	" " ...	129.0	128.8	910	0.2	2	0.2	
R. N. Y.	"	" " ...	112.5	112.0	806	0.5	7	0.9	
"	Scabby	" " ...	102.5	101.5	859	1.0	8	1.0	1.0
Plot II									
Delaware	Scabby	Cor. Sub. Sol...	121.5	118.1	739	3.4	20	2.6	
"	Smooth	" " ...	117.3	116.7	714	0.6	2	0.3	
R. N. Y.	"	" " ...	127.3	127.3	798	0.	0	0.0	
"	Scabby	" " ...	112.8	110.4	825	2.4	14	1.7	1.2
Plot III									
Delaware	Scabby	Formalin vapor (seed wet)	88.5	74.7	571	13.8	101	15.0	
"	Smooth	" "	90.2	84.8	645	5.4	49	7.1	
R. N. Y.	"	" "	123.9	121.5	939	2.4	22	2.3	
"	Scabby	" "	107.0	98.1	748	8.9	70	8.5	7.6
Plot IV									
Delaware	Scabby	Formalin vapor (seed dry)	127.1	124.7	693	2.4	17	2.4	
"	Smooth	" "	127.5	127.4	947	0.1	2	0.2	
R. N. Y.	"	" "	121.9	121.8	840	0.1	2	0.2	
"	Scabby	" "	137.0	135.4	896	1.6	14	1.5	1.1
Plot V									
Delaware	Scabby	Untreated.......	140.9	111.5	703	29.4	225	24.2	
"	Smooth	"	142.2	137.3	913	4.9	29	3.1	
R. N. Y.	"	"	134.7	130.1	907	4.6	39	4.1	
"	Scabby	"	103.5	77.4	617	26.1	200	24.5	13.6

DISCUSSION OF THE RESULTS

As in all previous trials, extending now through several years, corrosive sublimate and formalin have alike proved equally efficient. The aim in introducing them again this season was primarily to secure thereby a standard or basis for comparison. These solutions afford a cheap and eminently satisfactory means whereby the small potato grower may combat scab. For the large grower and the seed dealer who handles hundreds of bushels, a less laborious process is to be desired. It would be so much more economical and satisfactory in such cases to use a gaseous disinfectant that we have for several years been testing various methods looking to this end.

Without reviewing previous results[1] it may be said that they have pointed toward formaldehyde gas as the most promising candidate for favor. This is the standard disinfectant for use in hospitals and sick

[1] Vt. Sta. Rpt. 13, p. 273 (1900); 14, p. 231 (1901); 15, p. 225 (1902).

chambers for the destruction of germ life. Three methods have been tested with the gas. The generation of the gas from the dry pastilles by use of the Schering lamp is a very convenient method and gave good results in 1900, but less satisfactory ones in 1902, possibly due to loss of strength of the tablets used. We therefore in 1901 and 1902 used the more certain method of generating the gas by boiling the liquid formalin. In using this gas for destroying pathogenic bacteria it has been found that moistened surfaces are sterilized more quickly and surely than are dry surfaces. It seemed desirable, therefore, to test both methods with potato scab. This was done in 1903, with the results given above.

It will be seen at once that the dry treatment gave better results than did the wet. This is surprising yet seems perfectly clear from the figures. It is extremely gratifying that this is so, since the wetting of the tubers before fumigation would not be a practicable thing in many cases, whereas the dry process would always be feasible.

We are not yet fully satisfied that this dry fumigation process is equal to the disinfection attained by soaking the seed potatoes in formalin or in corrosive sublimate solution. These processes have been proved reliable by long experience, whereas this fumigation method should still be considered as in the experimental stage. In view of the several years' results, however, and especially of those of the last summer, dealers and large growers who do not consider the soaking process practicable under their conditions, are advised to use the fumigation process providing their storage room will permit it.

The method recommended.—Prepare to close the room as tightly as possible, (of course the smaller the room and the tighter it can be closed the better); place in a seamless kettle the required amount of formalin solution; set this on an alcohol or kerosene stove containing enough fuel to evaporate it fully; light the flame and retire from the room, sealing the door. Leave the room closed for 24 hours or longer. It remains an open question as to the exact amount of formalin needful. For disinfecting sick chambers, 5 oz. to each 1000 cubic feet is recommended. We used more than this and would recommend the use of not less than one pound for that space. Even more than that will not harm the tubers, as shown by our results.

NOTES ON CERTAIN THREATENING WEEDS

The Station considers that one of its duties is to watch for the appearance and spread of weeds new to the State. The worst pests already present in Vermont are usually foreign plants; and possibilities in the direction of these importations are far from being exhausted. The recent extension of the Rutland railroad through Grand Isle county is responsible for the introduction of at least two bad weeds, and has extended the range of others. This emphasizes the important role of the railroad in weed distribution.

KING-DEVIL WEED. (*Hieracium praealtum*)

This plant is closely related to the orange hawkweed and is said to equal it as a pest. It is established as a bad weed in north-eastern New York, in Maine and in south-eastern New Hampshire. A careful but unsuccessful search was made in Vermont for this plant in connection with our earlier studies upon the orange hawkweed. A specimen was brought to the Station in the summer of 1903 by Mrs. Nellie F. Flynn, gathered on the Rutland railroad track near the mouth of the Winooski river, Burlington. The plants found were promptly eradicated. It is to be hoped that it has not seeded or established itself elsewhere in that region. It is so serious a pest that farmers and railroad section men should strive to keep it out of the State. The plant closely resembles the orange hawkweed, differing chiefly in having slightly smaller flowers of a yellow color.

CREEPING SOW-THISTLE (*Sonchus arvensis*)

This is probably the hardest thistle to eradicate that occurs in grain fields. It is frequent in sections of Canada and is spreading into north-western Vermont, especially in Grand Isle county. This plant, like the king-devil weed, is apparently migrating by way of the railroads, but is probably carried in seed oats or other grain as well.

It is a conspicuous plant when in flower, having yellow dandelion-like blossoms, borne on stems, which raise them above the oats or other grain. They are open in July. Its perniciousness as a weed is due to its underground creeping root stocks, which enable it to spread under cultivation as does the Canada thistle and quack-grass. Farmers should be especially careful not to use or distribute for seed purposes oats containing seeds of this plant.

BLUE THISTLE (*Echium vulgare*)

This is an European weed occurring in New York and Canada. Until recently it was practically confined in this State to portions of Bennington and Rutland counties. It has appeared several times of

late years at scattered points along the Rutland and Central Vermont railroads, at Charlotte, Colchester, Burlington and Milton. Like the two plants just described it deserves the attention of both railroad section men and farmers.

Fig. 1. Blue Thistle. (After Fletcher.)

It is worst as a weed in moist rocky pastures. It is easily recognized by its deep blue blossoms about the size of pea blossoms, and its abundant covering of prickly hairs. The latter give it a thistle-like

character, whence its name, for it is not a true thistle. This should not be confused with the chicory or "blue-weed" which has round blue blossoms about the size and character of dandelion blossoms, borne on taller, smooth, much branched stems.

Fig. 2. Prickly Lettuce. (After Dewey.)

RUSSIAN THISTLE (*Salsola tragus*)

This tumble weed which caused so much alarm to the farmers of the north-west some years ago, was found last year in South Hero in an abandoned quarry from which ballast had been taken for the Rutland railroad. The single plant seen had not scattered its seed and, as it was promptly destroyed, it is hoped that it is exterminated. This is cited, however, as another illustration of how the railroads serve as weed highways.

CLOVER DODDER (*Cuscuta*)

The dodders are parasitic plants which twine about clover and other plants and kill them. They resemble tangles of yellowish fibres without leaves or conspicuous blossoms. One or more species have been introduced with clover seed and were sent to us from various localities during the past summer. They should be exterminated promptly whenever seen since they may prove the worst of weed pests of meadows if allowed to become established.

Fig. 3. Clover Dodder. (After Dewey.)

THE PRICKLY LETTUCE (*Lactuca scariola*)

This plant has in recent years come to rival the ragweed as an omnipresent annual in waste places in portions of the northern Mississippi valley. It also seems destined to spread in Vermont along the railroads, since it was first seen on the railroad track at Rouses' Point and, later, in the railroad yards at St. Albans. It has also been seen in waste places in Vergennes and Rutland. It will not prove as serious an intruder as any of the plants previously described, but it is an objectionable visitor which should be kept out at least as long as it can be. It is most easily recognized by the thistle-like appearance and curious habit of its leaves, which bear along the margins and in the mid-rib numerous rather soft prickles and which are usually so twisted at the base as to stand on edge tending toward the north and south plane. It is therefore a "compass-plant," the odd position of the leaves resulting from the influence of sunlight and directing one to the points of the compass.

THE SHRUBBY CINQUEFOIL AS A WEED.

I. INTRODUCTION

Weed problems are always in a measure local problems. Climate, soil and cultural conditions determine largely the character and prevalence of the weeds. We have seen no more striking illustration of this fact than that offered by the plant under discussion. As will be shown in detail later in this article, the shrubby cinquefoil, *Potentilla fruticosa*, is widely distributed in the north temperate zone, but, outside of a few limited areas, it is a botanical rarity. In certain sections, however, including parts of south-western Vermont, it has proved the most aggressive weed invader known to the farmers, taking almost complete possession of the pastures and pushing even into tilled lands. The Experiment station has been appealed to so frequently in regard to this plant that a systematic and fairly exhaustive study of it has been undertaken, with especial reference to its spread as a weed and its control.[1] Certain experiments are under way which will not be

[1] The shrubby cinquefoil has been an object of attention by the botanical department of this Station for several years. During 1902-03 Mr. O. B. Gilbert, a student in the Agricultural Department of the University, made it the subject of his senior thesis investigation. Mr. Gilbert's home is in Dorset so that he has had the best of opportunities for the study. He made a tour through the other infested regions in Vermont, Massachusetts and Connecticut and corresponded with various botanists in this country and abroad. He also took charge of the experiments with the Angora goats. The data accumulated by Mr. Gilbert has been used freely in this account and we hereby acknowledge our indebtedness to him and to his father, Mr. F. F. Gilbert. We are also under obligations to a large number of botanical correspondents in Vermont. and other states, in Canada and in Europe for answers to inquiries addressed to them by Mr. Gilbert and the writers, among whom we would especially mention Messrs, H. M. Thomson, Mass. Agl. Coll.; T. D. A. Cockerell, New Mexico Normal Univ.; T. S. Gold, Cornwall, Conn.; A. W. Lund, Vesteroik, Sweden; W. T. Thisleton Dyer, Royal Gardens, Kew, England.

completed for some time, but it seems inexpedient to delay publication awaiting their outcome.

II. NAMES AND DESCRIPTION

The plant passes under a variety of local popular names. *Shrubby cinquefoil* is the common name used by botanical writers, but it is rarely heard among practical farmers. This is, however, the best name available for general use.

Prairie-weed or *prairie-bush* is the name in most common use in Manchester and Dorset. Tradition has it that years ago a man, bringing a flock of sheep from the western prairies, turned them into a clean pasture, and, inasmuch as this weed appeared in the pasture soon after, it was inferred that the sheep brought the seed from the prairies.

The name *sage-bush* and *wild sage*, often heard in the infested areas in Vermont, may have had a similar origin, from the supposed relationship of this plant to the western sage brush. More probably these names were given it because of the gray-green, somewhat sage-like color.

Hawley-weed, also in local use in Manchester, takes its origin from the fact that the first pasture to become overgrown in one section was that of Major Jay Hawley, a large land owner of the middle of the last century.

Manchester-weed is a common name with people of the less infested towns bordering Manchester, though naturally its use receives little encouragement from the residents of this latter place.

Sandgate-weed is a local name said to be applied to it in the town of Sandgate.

Hardhack is the name usually given to *Spiraea tomentosa*, but the similar habit of this cinquefoil has led many farmers to apply it to the latter also. This is especially true in the infested regions of southwestern Massachusetts according to Thomson.[1]

Goshen hardhack or *Goshen-weed* is the common name in the vicinity of Goshen, Conn., where it is abundant.

Black brush is the name used by the ranchmen of Colorado, according to Cockerell.[2]

Chester-flower is the name given to the cultivated form in Loudon's Encyclopedia of Plants of Britain.

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[1] Thomson, H. M., Mass. Agl. Coll., Amherst, in correspondence.

[2] Cockerell, T. D. A., Normal University, Las Vegas, New Mexico, in correspondence.

GENERAL DESCRIPTION

The shrubby cinquefoil is a shrub from one to five feet high. In the young plant a few stalks branch out from the common base, but the number of these increases with age until there may be a score of them radiating to form a rounded bush, the lower nearly prostrate and, often, covering an area of twenty square feet or more. The bark, especially on the older stems, is shreddy. Five to seven leaflets are borne on each compound leaf. These have a grayish tint from a covering of silky hairs. From May until October the outer branches are dotted with pretty bright yellow flowers, about the size and general appearance of buttercups. These characters combine to make so pleasing a shrub that it is frequently used in ornamental plantings. The recent Cyclopedia of American Horticulture speaks of it as "a useful shrub, flowering throughout the year."

FIG. 4.

It is a matter of some practical as well as botanical interest to note that the plants obtained from nurseries which are in cultivation in shrubberies in Burlington, so far as observed, are sterile, the pistils or stamens being abortive. Hooker[1] states that in Teesdale, England, the flowers appear to be functionally unisexual, and "the sexes differ in appearance." Professor W. Thistleton Dyer in a recent letter to us, says that "this is true of other individuals of the same species collected in other countries and now contained in the Kew Herbarium." Observations on the plants of Newfane, Smuggler's Notch, and Lake Willoughby by Clifton D. Howe, when botanical assistant in 1901, showed all to have

FIG. 5.

Fig. 4. Sprig of shrubby cinquefoil showing leaf, flower and fruit, two-thirds natural size. (From nature by Miss E. K. Herrick.)

Fig. 5. Flower from a sterile (staminate) plant of the cultivated strain, doubtless of European origin, slightly reduced.

[1] Hooker, J. D., Student's Flora of the British Islands.

perfect flowers. He later examined those of plants on the Newfoundland coast and found them perfect. Observations in Dorset made by O. B. Gilbert showed all to be alike and perfect. The plants in culture at Burlington were probably imported stock. This suggests physiological differences which may determine in part the capacity of the plant to develop as a weed.

FIG. 6.

BOTANICAL NAMES AND RELATIONSHIP

The shrubby cinquefoil is a member of the Rose family, closely related to the common herbaceous weeds "five-fingers" and "silver-weed" of grass lands, and to numerous shrubby pasture weeds including the common hardhack or steeple-top (*Spiraea tomentosa*) and the brambles (*Rubus, sp.*).

The botanical name in general use is *Potentilla fruticosa*, Linn. Recently Rydberg[1] has placed it in a new genus as *Dasiphora fruticosa.* (L.) Ryd. Several varieties have been suggested from time to time, indicating a variability characteristic of members of the Rose family. Comparisons of our Vermont plants from Willoughby, Smuggler's Notch, Burlington and Manchester fail to convince us of any constant differences in morphology or habit. These plants do differ somewhat, however, from the plants used for ornament about Burlington and which, as stated above, are probably of European origin. Our native plants have more numerous flowers with shorter pedicels, leaflets more pubescent, and tending to be narrower with more revolute margins. Pursh[2] in calling attention to similar variations, as well as to difference in size when he proposed his new species *P. floribunda*, nearly a century ago, suggested that plants from various sources be planted side by side to see in how far these morphological differences would prove constant under the same environment.

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[1] Rydberg, P. A., Britton's Flora of N. States and Can. pp. 491, 499(1901).

[2] Pursh, Frederick, Flora N. Am. I. p. 356 (1814).

Fig. 6. Flower from a fertile (pistillate) plant, also probably of European origin, slightly reduced.

PROPAGATION AS A WEED

The plant forms a great abundance of seeds, a score or more per flower,[1] each slightly smaller than timothy seed, enclosed in a hairy envelope (an achene) which aids in its dissemination. These remain on the plant until winter. Most of them shed between December and March and are scattered by the wind, especially when there is a crust of snow upon which to drift. There is no reason to believe that they are ever carried by stock either in the hair or wool or through the manure.

FIG. 7.

The plant sprouts freely from the crown if cut back, but it does not spread by underground stems or roots, that is to say, it is not stoloniferous.

III. OCCURRENCE

HABITAT AND GEOGRAPHICAL DISTRIBUTION

Habitat.—The shrubby cinquefoil is at its best in cold, moist, rocky soil, preferably, according to evidence to be cited later, of limestone formation. It is not, however, closely confined to such a habitat as is shown by its remarkable development as a weed.

Geographical distribution.—Botanists find the species in the northern part of the north temperate zone throughout both hemispheres. It reaches into the Arctic circle in places, and extends well southward in the Himalaya mountains, and to the southern limits of the United States in the Rocky mountains. It is, however, essentially a plant of the cooler soils or higher altitudes. Although so widely distributed it has shown no weedy tendency outside of certain sections of New England and New York, with the possible exceptions of portions of Ohio, Indiana and Colorado.

OCCURRENCE AND DEVELOPMENT AS A WEED

The only serious developments are in New England. We will, however, for convenience, briefly state what is known of it in other sections.

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[1] A count of the achenes in a number of heads showed numbers varying from 5 to 48 with an average of 29.

Fig. 7. The hairy seed (achene) of the shrubby cinquefoil, much enlarged.

IN THE FAR WEST

Professor T. D. A. Cockerell states in a recent letter that "the shrubby cinquefoil is extremely common in the mountains of Colorado, in the Canadian and Hudsonian zones, wherever the ground is open in the immediate vicinity of the forests. That is to say it occupies the open ground skirting the wooded areas. In Wet Mountain valley, Colorado (altitude 9,000 feet), where I used to live, it is called 'black brush' and is quite troublesome to ranchmen."

Correspondence with the botanists of the Experiment stations of the Rocky mountain area failed to elicit further evidence of its weediness, although all familiar with that flora reported its occurrence. It seems fair to conclude that it is not generally troublesome in the regions where it occurs in the western states.

IN OHIO AND INDIANA

The shrubby cinquefoil has been reported[1] as showing weedy tendencies in moist soil in the vicinity of Castalia, Erie Co., where the overflow from the Castalia spring has left an abundant calcareous deposit.

It is common in the northern counties of Indiana in rich alluvial soil and "very troublesome in low fields in many places."[2]

IN VERMONT AT MANCHESTER AND DORSET

The conditions in these two towns will be described in some detail and this may serve as a basis for the discussion of other sections.

The worst occurrence of the plant is in the valley extending from two miles south of Manchester to Dorset village, a distance of about ten miles. It is no exaggeration to say that with rare exceptions every hillside pasture in Manchester is filled with this pest and the same is true of those of all of Dorset except in the north-west portion. A conservative estimate gives 5,000 acres as the area almost wholly occupied by this plant. This is a narrow valley of high elevation, about 1,000 feet, at the head waters of the Otter Creek and Pawlet rivers which turn north towards Lake Champlain and of the Battenkill river, the

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[1] Selby, A. D., Ohio Sta., in correspondence.

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[2] Coulter, Catalog of the Flowering Plants and Ferns and Allies Indigenous to Indiana. In Report of State Geologist of Ind., 19, p. 785.

course of which is southward to the Hudson. The soil is naturally rich. The hillside pastures, where most of the cinquefoil occurs, are rocky and moist, having in most places a gravelly subsoil. It is a limestone region with several marble quarries. The plant usually gains its first foothold in the moister situations, but it is by no means restricted to these. The tallest plants and most crowded growth occur in rich soil of a medium degree of moisture, and even the dryer summits of the rounded knolls are completely covered with its growth. It rapidly encroaches upon any field which is left unplowed for a few years, unless kept out by the closest pasturing and digging. The rapidity and completeness of its invasion may be illustrated by a specific case of a pasture of some thirty acres. Thirty years ago this was a clean pasture of the very best quality. Twenty years ago it was, generally speaking, free from this weed, but since that time the cinquefoil has rapidly increased, until to-day the field is scarcely worth fencing for pasture purposes. It is covered with an almost impenetrable matted growth from two to four feet in height, through which the cattle make their way only along narrow paths. The grass, even where the animals can reach it, is scant and spindling. (See Plate I.)

Without doubt the plant was a native of this section. Most of these fields were first cleared of forest and brought under cultivation a hundred years or more ago. During the first half of this period there seems to have been little trouble with the cinquefoil. Traditions date its first encroachments back some fifty years, and its serious development, at least in most sections, has occurred within thirty or forty years. The testimony is conclusive that it is extending its invasion into new territory in certain directions.

ELSEWHERE IN VERMONT

West and south of Manchester it is found in the adjoining towns of Sandgate and Arlington, though it is less troublesome here. Little of it occurs south of this point in Vermont until Pownal, the southern border town, is reached, when the back pastures are full of it.

North of Dorset there is little of it in the Pawlet valley, but it follows the course of the Otter Creek from the east side of the town northward through the towns of Danby, Tinmouth, Clarendon, Rutland and Pittsford, then it retreats to the hillsides on the east side of the valley where scattered areas occur in Brandon and Salisbury. The latter place, forty miles north of Manchester, marks its northern extension as a weed, and, indeed, so far as is known to us, no cultivated plants have been found, even by botanists, north of Salisbury, except in the Winooski gorge near Burlington, Smuggler's Notch of Mount Mansfield and the Lake Willoughby cliffs.

It is frequent in certain localities east of Manchester and Dorset in the valleys tributary to the Connecticut, and has been making somewhat alarming headway in recent years in sections of Stratton, Jamaica, Windham, Wardsboro, Newfane, and other portions of the West River valley.

Specimens have been brought to us from Strafford, fifty miles further north in the Connecticut valley, but no complaints have been made of it as a weed.

IN MASSACHUSETTS

In western Massachusetts, especially in the south-western portion, the development of the cinquefoil as a weed is similar to that of Manchester and Dorset. O. B. Gilbert, as a result of his observations, says: "in Berkshire county, Massachusetts, it is common in nearly if not quite every town; but that is not saying that it is common in every pasture by any means."

H. M. Thomson, late of the Massachusetts Agricultural College, who first informed us of its extensive occurrence in western Massachusetts, wrote us as follows in 1899: "It is abundant in the south-western part of the State. I am acquainted with it in my old home, Monterey, and in all the surrounding towns. I know it to be in Great Barrington. On the east there is a line passing through Blandford and Becket beyond which it does not go. I know of it in Pittsfield and Dalton on the north and it extends into Connecticut on the south. In the towns of Monterey, New Marlboro, Otis and Sandisfield nearly all the pastures and waste lands are covered with hardhack[1] to a greater or less extent."

IN NEW YORK

C. H. Peck, New York State botanist, writes us that he has seen it occupying moist pastures in Columbia county, which adjoins Massachusetts on the east.

IN CONNECTICUT

In Litchfield county, in north-western Connecticut, it occurs much as it does in western Massachusetts. Hon. T. S. Gold, Ex-Secretary of the State Board of Agriculture, who lives in this country and knows the weed, writes that "this region was settled about 1750. The hardhack[1] lands of to-day were then the best pastures and it is within the memory of our old men that it first became a troublesome pest. It spreads rapidly and now thousands of acres in this country are infested with it."

J. H. Putnam of Litchfield, adds further testimony along the same line. "Fifty years ago Goshen was the most noted cheese section in the country, but what were the finest dairy lands are now great areas of hardhack.[1] It takes many acres to keep a cow, and it hard to see where they get anything at all. Once valuable land is worthless because of this pest." Its prevalence here has led to its Connecticut name, "Goshen hardhack."

RELATION OF ITS WEEDY DEVELOPMENT TO SOIL CONDITIONS

The native habitat of the shrubby cinquefoil is always cool, moist and usually rocky situations. Its original stations in the areas under consideration were doubtless the borders of swamps and streams and in springy places. In its present occurrence as a weed it shows a decided preference for such situations, but it is by no means confined to them. Once established its abundant crop of seeds is annually broadcasted over all adjacent fields and the plants spring up everywhere from the summit of the gravelly knoll to the rich cultivated lowland.

The remarkable development of the plant as a weed in the clearly defined area under consideration suggests some favoring conditions other than soil moisture. The infested area in New England and New York, as described, extends in a narrow belt from Salisbury, Vt., at the north, with a slight interruption in south-western Vermont, through western Massachusetts, a little of adjacent New York and well into north-western Connecticut. All along this area it has sharp delimitations on both the western and the eastern borders. This region is outlined in the accompanying sketch.

It is a noteworthy fact that the badly infested areas are without exception calcareous soils, and, in most cases, they are in the limestone belt. This relation will become clearer by comparing the distribution of the weed with the limestone formation of western New England, as shown in the accompanying map, figure eight.

As bearing upon the apparent relation of calcareous soils to the weed, attention is called to the fact that the only area in Ohio known to be invaded with the shrubby cinquefoil as a weed is, as already stated, a soil strongly impregnated with lime as a result of its being flooded with the overflow from the famous Castalia springs.

We do not wish to imply that this plant is confined to calcareous soils. It does seem to us probable, however, that its rapid development as a weed is to be expected in such soils, and it is to be hoped that in soils of other character it may give little if any trouble. If this is the case it may be expected gradually to extend its area of invasion in the

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[1] Shrubby cinquefoil. See page 174.

FIG. 8. The above maps show the striking relation between the distribution of the shrubby cinquefoil as a weed in Vermont and the adjacent States, as indicated by the starred areas on the map at the right, and the calcareous rock formations indicated by the shaded areas on the map at the left.

Champlain valley in Vermont and to prove relatively less troublesome in the Connecticut valley.

IV. POSSIBLE ECONOMIC VALUE

It has been suggested that this plant has economic value. If so, it would be a happy thing to know of it.

Hon. T. S. Gold states that there was formerly some local manufacture in Connecticut of stable and street brooms from the branches of this cinquefoil. He suggested in correspondence that, although this industry has now ceased it might be revived profitably in case of scarcity or high price of broom corn. Retrius[1] states that a similar use of it is made by the inhabitants of the Swedish island Oeland.

A Manchester farmer has suggested the possibility that the plant may be used as a source of tannin, but we can find no evidence either in practice or in botanical literature that it has value for this purpose. An examination made in the chemical laboratory of the Station shows but traces of tannins.

The plant, therefore, has no use other than its doubtful ornamental value. The fact has already been mentioned that it is frequently used as are the related spiraeas for ornamental planting both in Europe and America. The plants handled by American nurserymen are, we believe, of European origin and their sterility (see page 176) commends them, since they will not form possible centers of infection. A remark by Mr. Gold on this point is pertinent. He says the United States Department of Agriculture in some of its earlier reports advised the use of this plant as an ornamental which was "very hardy." Mr. Gold adds that "if one of these advisers were to get into one of our hardhack lots with full grown, *hardy*, plants looking smooth and nice and as high as his head, when he were out for a ramble on a muggy day, he would rejoice when he reached a fence or some other sign of civilization."

V. METHODS OF CONTROL OR ERADICATION

PREVENTION

The rule that "An ounce of prevention is worth a pound of cure" is as good in fighting weeds as it is in fighting diseases. This is not a weed likely to be introduced with grass or grain seed or with manure. Its seeds are not carried long distances by the wind, at least not in great numbers. As already stated its invasion is probably wholly through seeds drifting on the snow crust in winter, and these in Ver-

[1] Retrius, A. J., Flora Oeconomica Suecisæ as quoted in correspondence by A. W. Lund of Vesteroik, Sweden.

mont fields cannot go long distances. If fields are free from it, it is not difficult to keep them free, unless they are in immediate proximity to infested lands. Even then it can be done as is amply shown by certain fields in Manchester. Some farms are practically free from the plant although adjacent and similar fields are overgrown. Their occupants control it in part by cutting out occasional plants, but chiefly by *heavily stocking their pastures* with cattle, so that everything is kept closely fed to the ground. High-grade, intensive, dairy farming will, in our judgment, keep clean the fields not as yet occupied by it. One dairyman who has had long experience with it, recently said "if I had to fight hardhack over again I should do it with bran." When the pasture is too large to admit of stocking the whole of it heavily enough to keep down the weeds, it will probably prove better in the end to fence off the back portions and let them grow up to trees at once, while heavily stocking the balance and giving it sufficient care to keep it free from this and other weeds.

These statements apply to land already free or nearly free from shrubby cinquefoil. It is not so easy to say what course is best with the fields completely occupied by it. The following discussion summarizes our present judgment regarding this matter.

BURNING

If a fire is started in a thick field of the cinquefoil in early spring, just after the snow goes off, the tops burn readily and most of them are destroyed. An abundant crop of young sprouts comes up from the base of each stem, however, and since the burned-off stubs are unpleasantly sharp and prick the nose of cattle, the stock allow these to grow and, hereby, but little is gained. It is said that burning two years in succession improves conditions. This method, however, seems to have found but little favor with farmers in the infested regions. At best it is only temporizing with the evil. Possibly the combination of burning with the use of goats, or with reforestation, as discussed later, may prove desirable upon further trial.

MOWING

What has been said of burning will in general apply to mowing. Ordinary farm stock will not crop the second growth close enough to keep it down, so this again only gives the plants a temporary setback. Mowing may be a good practice where the plant is just coming into the pasture. Occasional mowing will not kill the plant, however, as may be seen in numerous wet meadows where the plants are mown annually with the hay.

PLATE I. A view of pasture lands overgrown by the shrubby cinquefoil, Dorset, Vt. This land was the best of pasture twenty-five years ago. It is not "exhausted" or "worn out," yet is now practically valueless for pasture purposes because of the dense shrubby growth of this plant.

PLATE II. Two Angora goats inclosed in a half-acre of the weed infested pasture of Mr. F. F. Gilbert, Dorset. They have stripped the leaves completely from every shrub in the enclosure. Compare the dark naked branches here shown with the abundant foliage shown in Plates I and III, photographed on the same day. (See page 86)

PLATE III. This shows the peculiar antagonism between the butternut and the shrubby cinquefoil. The ground is fully occupied by the latter except for the circle surrounding the young butternut tree at the right center of the field. Not a living plant of cinquefoil occurred within the circle shown as a dark ring. At the left are trees of two or three other kinds none of which show such antagonism. (See page 188)

PLATE IV

Fig. 1. A nine-year old apple tree completely girdled by the round head borer. (See page 205.)

Fig. 2. A two-year old borer removed from his tunnel. (p. 205)

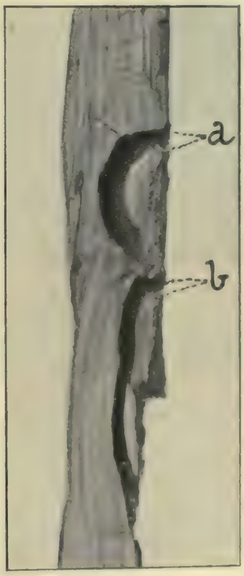

Fig. 3. A portion of the trunk of an apple tree showing two tunnels from which the mature insects have emerged at a and b. (p. 205)

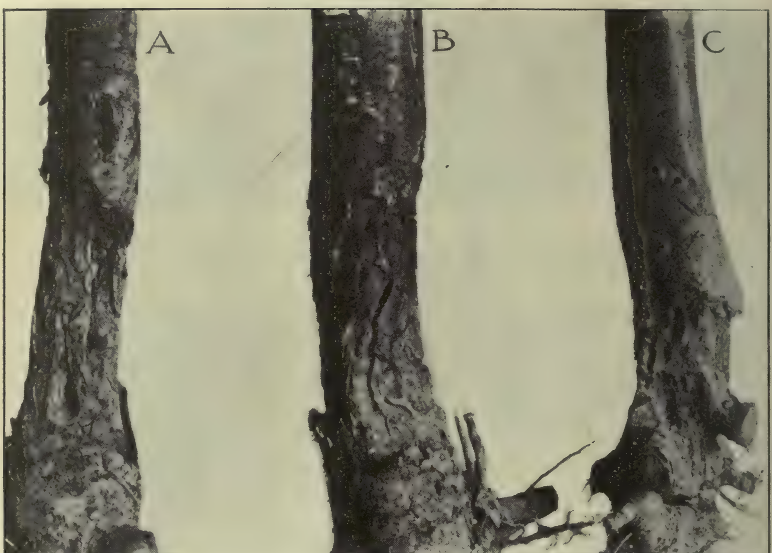

PLATE V

Trunks of three apple trees ruined by borers. The circular holes in the upper portion of trunks B & C were made by the mature insects when they emerged from the tree. (See page 205)

From the middle of July to the first of September is probably the best time for mowing this as is the case with most shrubby growths. The plants may be cut off with a grub hoe just beneath the surface, thus leaving fewer stubs. A method recommended as accomplishing the same end in a more satisfactory manner is that of knocking the plants out with an axe or grub hoe when the ground is frozen.

PLOWING, GRUBBING AND PULLING

Plowing with grubbing and pulling out the larger stools is the only method fully endorsed by most practical farmers in the infested regions. The general method is to go into the field with a strong team, heavy plow and two or three men. All except the largest plants can be turned out with the plow. The largest must be grubbed out or pulled with horse and chain. After picking up the plants that are thoroughly loosened the piece is gone over with a spring tooth harrow to loosen up and drag out the rest. The plants are piled and in forty-eight hours, if the weather is dry, all except the largest roots will burn. Three men with a strong team will clear up from one-fourth to three-fourths of an acre a day. To hire this crew will cost about $6.00, making the cost from $8.00 to $24.00 an acre. This, unfortunately, is more than most of the land is worth after it is cleared. Frequently such work can be done at leisure times with the regular farm help, under such circumstances the cash outlay is really less than appears in this estimate.

A common practice is to sow buckwheat the first year, potatoes or winter rye the year following, and then to seed down with grass. It is the testimony of those who have so cleared up cinquefoil fields that the land occupied by it is in excellent condition when reclaimed, apparently having been improved rather than exhausted by its occupancy.

THE USE OF STOCK

CATTLE AND SHEEP

Cattle and sheep will browse the cinquefoil somewhat, but they refuse to make it a steady diet. Hon. T. S. Gold writes that "it can be discouraged with close pasturing and some grain feeding. . . . . Twenty years ago I had a four acre pasture lot too rocky to plow or mow, covered with hardhack. I put my summer milking yard in a corner and sixty cows cropped it or lay on it for the night. The result is the hardhack has disappeared almost entirely." H. M. Thomson says, "Cattle and sheep eat the tender shoots. . . By burning it two

springs in succession and then stocking heavily with sheep or cattle the plant will be kept down for a time."

In short, the general testimony is that heavy stocking of the threatened pastures *which are free from* the weed, supplementing the pasture with grain as needed, will keep the weed out, but that it is practically impossible to kill out a fully established growth of it in this way.

ANGORA GOATS

This animal has been widely heralded during recent years as an aid in killing brush in pastures. It has, therefore, seemed worth while to make trial of it in connection with this particular problem. Two young ewe goats were sent in May, 1902, to Mr. F. F. Gilbert, Dorset, for trial. He inclosed them in an area of one hundred square rods in a corner of his pasture which was completely overgrown by this plant. They have been kept there now during two open seasons. A small stream crosses one corner of the area and furnishes the animals with water. They have been given salt occasionally, but, aside from that, have had nothing from outside of the enclosure. Practically all the choice the goats have had as to food is that between cinquefoil, grass and the hay-scented fern.[1] They have shown a preference for the cinquefoil as between these. In order to keep the grass and ferns and herbaceous weeds cropped back, two sheep were placed in the inclosure during midsummer of each 1902 and 1903. These sheep do not touch the cinquefoil. The outcome to date is promising, but not enough time has elapsed to make it decisive.

The summer of 1902 was a wet one, hence unfavorable for the goats and favorable for the plants. Nevertheless the goats soon stripped most of the foliage from the cinquefoil, and they have continued since to browse the young growth back about as fast as it has appeared. (See Plate II, opposite page 185.)

In July, 1903, when the last observations were made, many of the branches of the cinquefoil were dead, but a majority were continuing to send out struggling young shoots. Most of the stools were sending up some shoots from the base also. Since the goats were cropping these off promptly it seems probable that few plants in this area will survive the winter of 1903-04. Whether the goats fully exterminate the weed or not they certainly will come near to doing so. By keeping the foliage browsed from the bushes the sunlight is admitted so that the value of the grass in the area is already doubled or trebled.

We are not as yet posted as to whether Angora goats will or will not prove satisfactory or profitable as farm stock in New England. Most

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[1] Dicksonia pilosiuscula.

writers in the agricultural press claim that they will; but it is to be remembered that such press reports are apt to originate with goat dealers and fancy breeders rather than disinterested farmers. There are certainly some disadvantages and drawbacks in the way of liability to disease, difficulty in rearing the young, and expense of fencing which are not commonly presented.

These goats have been inclosed with a forty-two inch woven wire fence set close to the ground, and have never jumped out. They have shown no tendency to disease. They were allowed to run with a buck goat during part of December and January, but did not breed.

In conclusion, the hope is expressed that the Angora goat may prove a valuable aid in subduing if not wholly exterminating this plant, together with hardhack or steeple top[1] and similar shrubby growths in Vermont pastures.

Reforestation

General remarks.—There can be no doubt that considerable areas of so-called pasture lands in Vermont and the other New England states are destined to revert to tree growth in the near future. The increasing value of wood for lumber and pulp, and the scarcity and high price of farm labor, combine with various other causes to insure this outcome. It is beyond doubt that the sooner tree growth begins upon certain classes of land the better it will be for the next generation and for the State as a whole.

In so far as pasture weeds like the orange hawkweed, brake, hardhack and shrubby cinquefoil force upon the doubting landowner the wise decision to fence off such portions of the back pastures as are practically worthless for stock grazing and permit trees to take possession, they may indeed be blessings in disguise. This will seem to many a harsh and heartless doctrine. If understood aright, it is not so. Nature is kindly, if her laws are heeded; but those laws are changeless, and he who opposes them must suffer and meet sure defeat. A more liberal fertilization and a heavier stocking of the lower and better pastures, combined with gradual relinquishment to forest growth of the poorer and less accessible ones, is the inevitable course before Vermont farmers.

Fortunately the shrubby cinquefoil is killed quickly by tree growth of any kind. If stock is fenced out of a field trees will soon come in, and the cinquefoil weaken and die out as the trees overshadow it. It will probably be more profitable thus to encourage tree growth in many infested fields than to try to reclaim them by plowing or stocking. If

[1] Spiræa tomentosa.

this is to be done it may be profitable to plant certain kinds of trees to occupy at least a portion of the ground rather than to leave the development entirely to nature.

WHITE PINE

We are convinced that where white pine grows well plantings of this tree will prove profitable. Land that is to be planted should be burned over as early as possible in the spring. White pine seedlings from the nursery should be set in April or early May, as soon as the buds start. These may be bought as a rule cheaper than they can be grown, viz., $5.00 per thousand, more or less, depending upon the number ordered. It will take 1,200 trees to the acre. If the planting is done with a mattock it is said that two men experienced in planting will set the trees on three-fourths of an acre daily. Judging from the results where a few young pines are growing in an infested field in Dorset, the cinquefoil will not yield to them as quickly as to some other kinds of trees.

YELLOW LOCUST

Locust trees may be grown with profit for posts and deserve trial planting in infested areas.[1] They make a very rapid growth, are easily started from seed and transplanted, and when cut reproduce themselves from the root. We know nothing as to how quickly they would overcome the cinquefoil.

WILLOWS

Concerning tree-planting in relation to the cinquefoil, Mr. Gold writes as follows: "In one field I planted one half acre with gray willow scions from Illinois, thirty years ago. They grew well and checked the hardhack. In about fifteen years I cut a good crop of firewood, and now there is another crop. Willows are better than nothing."

BUTTERNUTS

A remarkable thing observed in connection with shrubby cinquefoil is the apparent antagonism existing between it and the butternut tree. This is a matter of common report with the farmers of Manchester and Dorset and careful observations by the writers have confirmed their idea. The cinquefoil rarely grows close to a butternut tree. This fact is strikingly shown where butternut trees occur in fields overgrown with the cinquefoil. Each large tree occupies the center of a clear grassy circle of a diameter considerably exceeding

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[1] See Vt. Sta. Rpt. 15 pp. 239-243 (1902), for statements as to locust growing.

the farthest spread of its branches. The deadily influence of the butternut is made even more evident in the case of rapidly growing young trees by the fact that the base of the tree forms the center of an area of dead cinquefoil plants. (See Plate III, opposite page 185.)

Moreover with such butternuts the "dead line" for the weed is pushed outward year by year as the tree enlarges so that the trees may be surrounded by a circle of dead and dying cinquefoil plants bordering the clean grassy plot under the tree. This antagonism is, we believe, attributable rather to the root relations of the two plants than to those of shade. Thus young butternuts from two to eight feet high were observed to be surrounded by a circle which might be twice the diameter of the top of the tree within which the weeds were dead and with dying plants bordering its margins. Such butternuts do not cast much shade. Moreover, young birch, beech, maple, cherry, apple, and pine trees in the same field showed no such striking relation to the death of the cinquefoil, healthy plants of the weed frequently crowding close under their branches.

In order to secure further data as to the root relations of these two antagonistic plants, one of our student assistants, A. H. Gilbert, was commissioned to dig up the dead and dying cinquefoil in the vicinity of some butternuts at Dorset. He recently did so and, while he wishes to make further observations another summer before considering the evidence fully satisfactory, he was led to conclude that the butternut roots are in some way attracted to the area occupied by the cinquefoil roots. In every case examined, the dead or dying cinquefoil clusters within the affected circles had butternut roots of considerable size passing directly underneath or close alongside the base. In several cases two or more butternut roots, growing from different directions, intersected directly in the root clusters of the cinquefoil; and there were no other butternut roots within some distance of these plants. One butternut root twelve feet long and about one-half inch in median diameter was followed from the tree to its terminus, and it was found to pass immediately under two successive clusters of the weed and to be growing directly toward a third. The bunch nearest the tree, and which was reached first by the root, had evidently been dead some years, since the top was rotten and the stems easily pulled from the root. The second was dead, but sound, showing a more recent death. The third was still living.

Another observation by Mr. Gilbert, showing that the fatal influence of the butternut is from root rather than foliage relations, was as follows: Near a large mature butternut tree and well within the circle where the weeds had elsewhere been killed, several green healthy

cinquefoil plants were observed in striking contrast to the rest of the circle. Upon investigation it was found that these were growing in very thin soil, overlying a ledge which so rose as to form a barrier over which no butternut roots had passed in this direction. In another case the cinquefoil plants were all killed except in a wet spot. The soil was not dug up, but we are now inclined to believe that the immunity of these weed plants was because there was so much water as to prevent the growth there of the butternut roots. No evidence of root parasitism was detected in any case, although sought for. The suggestion is rather that the invasion of the soil by the more vigorously growing butternut roots which develop near the surface may interfere with the nutrition of the cinquefoil in some way. The matter is certainly deserving of further investigation.

From the practical standpoint it is evident that the butternut should be given a prominent place in any scheme of reforestation looking to the extermination of the cinquefoil. One young butternut on each square rod of infested soil would probably in ten years' time kill most, if not all, of the cinquefoil.

REPORT OF THE BOTANISTS

L. R. Jones and W. J. Morse

Owing to the absence of the botanist during the past summer, attention in this department has been largely confined to the continuation of work already under way. Report is herewith presented upon the following subjects:

Occurrence of Plant Diseases in Vermont in 1904.

Potato Diseases and their Remedies.

- I. Results from spraying potatoes in 1904.
- II. Relation of date of digging to development of rot.
- III. Does liming prevent rot?
- IV. Disinfection of scabby potatoes by formaldehyde gas.

An Inspection of Grass and Clover Seed.

OCCURRENCE OF PLANT DISEASES IN VERMONT IN 1904

WEATHER CONDITIONS

Since the development of plant diseases is largely influenced by weather conditions, the following tables[1] are inserted, which give a summary from the weather records for Burlington and Northfield covering the growing period. The Burlington record represents fairly well the conditions in the Champlain valley and in the southern part of the State, while the Northfield record probably indicates quite closely the conditions in the northern and central parts.

	Mean temperature	Mean temperature for 21 years	Total rainfall	Average total rainfall for 21 years	Number clear days	Number cloudy days	Number partly cloudy days	Date killing frost
Burlington								
May	60.9	58.6	2.99	3.12	20	6	5	..
June	65.2	67.8	2.37	3.36	12	7	11	..
July	69.0	71.5	4.19	3.91	11	14	6	..
August	66.7	68.8	2.56	4.14	17	10	4	..
September	57.8	61.8	5.84	3.59	8	12	10	23
Average for 5 months	63.9	65.7	3.59	3.62	..	..	..	..
Total	....	....	....	....	68	49	36	..

[1] The Station is indebted to Mr. W. B. Gates, voluntary observer at Burlington, and to Mr. W. A. Shaw, observer at Northfield of the Weather Bureau of the United States Department of Agriculture, for the records.

NORTHFIELD		For 18 yrs.		For 18 yrs.				
May	57.1	53	2.30	2.67	11	8	12	..
June	60.6	62	1.33	3.12	7	10	13	..
July	64.0	66	3.53	3.59	2	11	18	..
August	60.9	63	3.54	3.89	9	9	13	..
September	53.2	56	5.06	2.83	9	16	5	23
Average for 5 months	59.1	60	3.15	3.22	..	..	..	..
Total	....	....	....	....	38	54	61	..

It will be seen from the above tables that omitting May, the mean temperature month by month was from one and one-half to four degrees lower than the average for the last two decades. The mean temperature for the entire five months was nearly two degrees lower than the average for the last 21 years at Burlington and nearly one degree lower than the average for the last 18 years at Northfield. The rainfall of May and the total for the five months was about up to the average. The total rainfall for the three summer months was two and one-quarter inches less and of the month of September two and one-quarter inches more than the average of the two decades. The effect of this cool dry midsummer period was in general to reduce the loss from parasitic fungi, and of the excessive rainfall of September to induce an unusual amount of potato rot.

POTATO BLIGHT

During the months of August and September potato fields were examined in many points in northern and central Vermont. Almost without exception there was an abundance of strong, healthy tops, but somewhat late in development. This latter condition was partly due to late planting and partly to the low temperature and comparative dryness of the summer months.

Considerable arsenical poisoning was noted, which in every case investigated was found to be due to improper methods of application. In some localities, especially on the sandy soils near Burlington, early blight was very destructive. Many fields, particularly where the foliage had been weakened by tip-burn and improper use of arsenites, were entirely destroyed by this fungus early in August.

Late blight did not appear as early as usual, being ten days later than in 1903 and over a month later than in 1902. The first blighting leaves were observed in Burlington on August 21 and in Irasburg on August 23. From this time on through September it developed very slowly and though widely reported, did less damage to the foliage than usual. Consequently the gain in total yield from spraying potatoes with bordeaux mixture was below the average. However, as a protection against the dry rot of the tuber, resulting from late blight,

the returns from spraying were highly satisfactory, as will appear later.

While spraying did not serve as a preventive of early blight, apparently much less damage was done by this fungus to sprayed than to unsprayed plants.

DISEASES OF FIELD CROPS

Occasional blighted leaves have been observed in the corn fields of the Station farm for the past two years. Examination showed the trouble to be due to the fungus *Helminthosporium inconspicuum*, C. & E. While blighting leaves were not uncommon, serious damage seldom occurred. During the past season, however, one field was quite thoroughly infested by this fungus. Nearly every leaf in some parts of the field showed one or more blighted areas, and without doubt the value of the crop was materially lessened as a result.

ORCHARD DISEASES

Apple and pear scab seemed more prevalent than in the preceding year. Considerable damage both to foliage and plants occurred with susceptible varieties which were not protected by spraying.

A twig blight and apple canker were found in one large orchard, due apparently to the attacks of a parasitic fungus, the nature of which has not as yet been determined.

By far the most serious injury to Vermont orchards during the year was caused by the peculiar weather conditions of the winter of 1903-4 and, possibly, of the preceding summer. From the middle of April, 1903, to the first week in June an unbroken drought obtained throughout the East. As a result, while the trees put forth foliage as usual, there was no real active growth till after the rains came in June. Consequently the growing season was shortened and, doubtless, much of the wood failed to mature. Such wood was ill-fitted to endure the winter weather of 1903-04, one of the most severe seasons that has been experienced in Vermont in years.

During May and early June, 1904, the Station was constantly importuned from all parts of the State as to a peculiar trouble affecting apple, pear, plum and cherry trees. In most cases correspondents reported that the trees began to put forth foliage and often blossomed profusely. As this stage was reached, however, the flowers suddenly began to drop off and the leaves to wither and die. An examination of the small twigs where the leaves had begun to dry up showed, on following the branch down, a depression where the cambium was dead. The bark appeared shrunken and withered. The dead

cambium often extended to the larger branches and frequently, in the case of young, actively growing trees, to the base of the trunk itself. Trees in this condition were observed by one of the writers all through the central and eastern part of the State and as far south as northern Massachusetts. Professor W. T. Macoun of the Central Experimental Farm, Ottawa, in correspondence reports many trees injured in this manner and large numbers of them killed outright, as was also the case in Vermont. An examination of the diseased trees in many orchards led to the conclusion that the trouble was due to winter killing. The trees most badly affected were usually in the more exposed locations. The Station horticulturist also gave attention to this malady and makes brief statements concerning proposed remedial treatment in his report.

GARDEN VEGETABLES AND SMALL FRUITS

No reports were received as to the prevalence of soft rots of vegetables. There was an outbreak of bacterial rot of turnip in the station garden in 1903. Turnips and cabbages were planted on the same area in 1904 to see whether the disease would reappear. It did so, indicating that the organisms remain in the soil in destructive numbers.

The red rust of the blackberry and asparagus rust were very prevalent during the past season, much more being observed than for several years past. A blackberry cane blight (*Gloeosporium, sp.*) was reported from the southern part of the State.[1]

POTATO DISEASES AND THEIR REMEDIES

I. RESULTS FROM SPRAYING POTATOES IN 1904

This makes the fourteenth consecutive year in which records have been kept at this Station of the results obtained from the use of bordeaux mixture for spraying potatoes. As in 1903 one application made between the 10th and the middle of August was sufficient to protect the foliage from late blight. However, where another application was made during the last week in August or the first of September there was much gain resulting from the protection of the tubers from rot caused by the late blight fungus.

Records as to results obtained from spraying potatoes were kept on parts of three different fields. Field number one was a some-

[1] This may be *Gloeosporium navioulisporum,* Stoneman. The spores are similar in appearance to those of *G. nariculisporium*, but Miss Stoneman reports that some of these measure twice the length of those of that species.

what sandy loam which had been in grass for several years. A heavy dressing of manure was plowed under in early spring. No commercial fertilizer was used. It was designed to plant early in May, but as circumstances prevented the ground being fitted at that date, these plots were planted on May 28. The variety used was Delaware, at the rate of sixteen bushels per acre, the seed having been previously disinfected for scab by soaking in formalin solution. One application of paris green was made on the entire field about July 10. On July 26 and on August 25 rows 4, 5, 6, 10, 11 and 12 received thorough applications of standard bordeaux-paris-green mixture. Rows 1, 2, 3, 7, 8 and 9 were sprayed at the same time with paris green in water, the amount of this poison being the same on all rows.

A careful record of the growth and the condition of the tops was kept during the growing season. By July 20 the plants were about one foot high and beginning to blossom. On August 20 the vines were very large and healthy, two feet or more in length and nearly covering the ground. No early or late blight was found, and the plants still showed a few flowers. The sprayed and unsprayed foliage looked entirely alike at this date. Early blight began to develop during the first week in September, and, on September 6, the unsprayed rows showed more early blight and tip burn on nearly every hill. The sprayed rows were quite healthy on this date. On September 20 the foliage on the unsprayed rows was two-thirds dead from early blight and tip burn. A small amount of late blight could be seen on the unsprayed rows at this time. The sprayed portions were quite healthy, with a few leaves on each hill showing early blight. The plants on the entire field were killed by frost on September 23.

The crop was allowed to remain in the soil until October 15 before digging. At this time there was no indication that any of the tubers had entirely decayed, in fact few were very badly decayed. Therefore, the results given for the total yield is probably very near the exact figure. In this connection it may be well to call attention to certain facts already stated, namely, that no manure was used except that which was plowed under in early spring; that the crop had almost no care whatever, except spraying; and that owing to the lateness of planting, the growing season of the crop, three months, was very short. However, returns from the sprayed portion were far better than those from the average Vermont potato field. The same may be said in a less degree of the unsprayed portion; but had the blight appeared as early as it has frequently in the past it is safe to say that the crop would hardly have paid for harvesting.

Following are the results stated in bushels per acre:

	Total yield	Sound tubers	Decayed tubers	Percent of decay
Sprayed	294	293¾	¼	0.1
Unsprayed	234	204	30	13.
Gain	60	89¾	..	...

Field number two was a part of the main potato field of the Station farm. It had been in corn for two years, and for three years, including the present, had received a liberal application of stable manure. No commercial fertilizer was used. The soil resembled that in field number one, being, however, somewhat less sandy and slightly more moist.

The variety used was Delaware, planted May 25. The piece received the same attention that the remainder did, both as to hoeing and to spraying, which were done by the regular farm help. The crop was sprayed twice, August 5 and September 1. At the time of the first spraying a portion of the field as near like the adjoining as possible was left unsprayed. Until killed by frost on September 23 the plants were in a fairly healthy condition, although on account of the lateness of the season they had begun to weaken considerably towards the last. Some early blight and considerable injury from flea beetles and other small insects were noted. The sprayed portions appeared to have been less troubled by insects than the unsprayed. The unsprayed rows were just beginning to develop late blight, although it had not progressed far enough to do material damage to the foliage or even to be apparent to the average observer.

The plots were not dug until October 28, when the following results were obtained, expressed in bushels per acre:

	Total yield	Sound tubers	Decayed tubers	Percent of decay
Spryaed	370	370	0	0
Unsprayed	368	320	48	13
Gain	2	50	..	..

Field number three was a clay loam soil, and consisted of about one-third acre, located on one of the most travelled highways leading in the city, admirably situated for use as an object lesson in spraying. The seed—variety unknown—was planted about the middle of May. The plants were in fine condition and very uniform all over the piece by the first of August. Sixteen out of twenty-four rows were sprayed twice with standard bordeaux mixture on August 9 and September 5. The first blight was seen on the unsprayed rows on August

21, but the progress of the disease was exceedingly slow all through the month of September. On September 23 the plants were all killed by frost. At this date at least 90 percent of the leaves on the sprayed rows were alive, the remainder having been killed mainly by insect injuries and early blight. No late blight was seen on any of these. Fully 95 percent of the foliage on the unsprayed rows had been killed, largely by late blight.

The plots were dug on October 3. The sprayed and unsprayed portions for the record were carefully selected to secure uniformity of conditions and the two outside rows where the sprayed and unsprayed plots joined were rejected. The results, calculated in bushels to the acre, are as follows:

	Total yield	Sound tubers	Decayed tubers	Percent of decay
Sprayed	344	317	27	8
Unsprayed	301	56	245	81
Gain	43	261	..	..

The following gives a summary of the results obtained from the three different spraying experiments:

	Total yield in bushels per acre		Increased total yield in bushels per acre	Rot in bushels per acre		Net gain from spraying in bushels per acre
	Sprayed	Unsprayed		Sprayed	Unsprayed	
Field No. 1	294	234	60	¼	30	90
Field No. 2	370	368	2	0	48	50
Field No. 3	344	301	43	27	245	261
Average	336	301	35	9	108	134

DISCUSSION OF THE RESULTS

The gain in the total yield was not so large as usual. This was due to the very late appearance of the blight. Early potatoes were all out of the way and, in most cases, the late varieties had nearly reached their maturity before they were attacked. Even then the progress of the disease was so slow that it was only a slight check upon the growth of the crop. Much spraying done in Vermont during the season of 1904 was probably done at a loss, when considered as foliage protection only. This was the case in field number two, while fields number one and three paid a fair profit on the investment. On

the other hand the results attest in a remarkable way to *the value of spraying as a protection against the rot of the tuber.* This is well shown in the records for field number three, where the sprayed portion yielded 317 bushels of sound tubers per acre and the unsprayed only 56 bushels per acre. This gives a net gain as a result of spraying of 261 bushels per acre, or 466 percent gain. When the crop was dug potatoes were selling in Burlington at from 50 to 60 cents per bushel. This makes an increase of from $130 to over $156 per acre in the value of the crop obtained. This is, to be sure, an exceptional case; but we learned of several fields during the fall where the rot was as bad, and in some instances where it was worse, than this. A few reports were received where the owners did not consider the crop worth the cost of digging. The Station farm raised over 1,700 bushels fit for table use on less than five acres of land. The soil on at least half of this field was practically the same as on field three. The crop was sprayed twice. Little or no rot was found when dug and the potatoes readily brought 60 cents per bushel in the city.

Why should there be so much less late blight of the foliage and so much more loss from rot this year than usual? Probably the explanation is to be found in the weather conditions of the season. Leaf disease was held back by the dry growing period of June, July and August, and the tuber rot was promoted by the wet September. There were only eight clear days during that month, and rain fell on fourteen days. Nearly one-third of the rainfall from May 1 to October 1 occurred in September. The precipitation was 5.84 inches or 2.25 inches more than the average for this month for the last twenty years. The mean temperature was also four degrees below the average for the last twenty-one years. The soil was continually soaked with water, with no sunshine to dry out the surface. This furnished admirable conditions for the falling spores to infect the tubers near the surface. It is a significant fact that the amount of rot found per acre in each field is more or less proportionate to the length of time in which the blight had been developing on the foliage. Field number three, when it had been established over a month, gave 245 bushels of rotted tubers, while on fields one and two, where it had just appeared, produced only 30.4 and 48 bushels of decayed tubers per acre.

In conclusion we give in tabular form the results of experiments at this Station for fourteen successive years, including for the current year the average of the results from the three fields.

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre		Gain per acre
			Where sprayed	Whe'e not sprayed	
White Star...	May 11, 1891.	Aug. 26, Sept. 8.........	313 bu.	248 bu.	65 bu.
" " ...	May 20, 1892.	July 30, Aug. 18, 25......	291 bu.	99 bu.	192 bu.
" " ...	May 20, 1893.	Aug. 1, 16, 29............	338 bu.	114 bu.	224 bu.
" " ...	Apr. 26, 1894.	Jnne 16, July 17, Aug. 30	328 bu.	251 bu.	77 bu.
" " ...	May 20, 1895.	July 25, Aug. 13, 31.....	389 bu.	219 bu.	170 bu.
Polaris.........	May 15, 1896.	Aug. 7, 21...............	325 bu.	257 bu.	68 bu.
"	June 1, 1897.	July 27, Aug. 17, 28.....	151 bu.	80 bu.	71 bu.
White Star....	May 10, 1898.	July 21, Aug. 10.........	238 bu.	112 bu.	126 bu.
Average 3 var.	May 18, 1899.	July 26, Aug. 17, Sept. 8	229 bu.	161 bu.	68 bu.
Delaware	May 23, 1900.	Aug. 4, 23...............	285 bu.	225 bu.	60 bu.
"	May 25, 1901.	July 20, Aug. 21.........	170 bu.	54 bu.	116 bu.
"	May 15, 1902.	Aug. 1, 20...............	298 bu.	164 bu.	134 bu.
Green Mount.	May 1, 1903.	Aug. 10..................	361 bu.	237 bu.	124 bu.
Delaware......	May 25, 1904.	About Aug. 1 & Sept. 1	327 bu.	193 bu.	134 bu.
Average for fourteen years..................			289 bu.	173 bu.	116 bu.

II. RELATION OF DATE OF DIGGING TO DEVELOPMENT OF ROT.

When potato tops are blighting, is it better to dig at once or not? This is a practical question often asked and the lack of scientific information and of uniformity in practice alike show the need of its investigation. Trials were made and reported upon in 1902 and 1903,[1] and those of 1904 were in continuation thereof.

The soil conditions and planting were as follows: Grass land, good sandy loam, well drained, with liberal application of stable manure; potatoes planted May 28; varieties, Green Mountain, Delaware, Rural New Yorker No. 2, Polaris, Early Rose, Early Ohio. Ten rows were planted to each variety, 3 feet apart and 91 feet long, i. e. one square rod per row. The seed was not uniformly good, especially the Early Rose and Green Mountain, so that the relative yields of the different varieties have little significance. A single application of paris green was made early in July, but otherwise no spraying was done. Two rows of each plot were dug on each date, August 22 and 29, September 5 and 12, and one row of each on September 19 and 26.[2]

The condition of foliage as noted by the field observer was as given below. The appearance of the rot in the tubers from the earlier diggings justifies the conclusion that the late blight fungus was actually

[1] Vt. Sta. Rpt. 15, p. 219 (1902); 16, p. 161 (1903). See also Soc. Prom. Agl. Sci. Proceedings 25, p. 91 (1904).

[2] The yields from the rows dug Sept. 19 and 26 as shown in the table, have been multiplied by two so as to make them comparable to the other plots.

present in small amount on the foliage at an earlier date than is here recorded. The notes are however here reported as they were made in the field. The accompanying weather conditions were discussed earlier in this report.

Green Mountain.—August 22, plants in healthy condition, no blight, mostly past blossom. August 29, green and healthy. September 5, foliage mostly green, little early blight. September 12, one-fourth of the leaves dead from early blight, late blight doubtful. September 19, three-fourths of the foliage dead, chiefly from early blight. September 23, killed by frost.

Delaware.—August 22, good condition; tops covering the ground, just past blossoming period, no blight. August 29, green and healthy. September 5, fairly healthy, some early blight. September 12, one-fourth of leaves dead from early blight with a few questionable cases of late blight. September 19, foliage entirely dead.

Rural New Yorker No. 2.—August 22, green and healthy, just past flowering stage. August 29, green and healthy. September 5, quite healthy, some early blight, and possibly a little late blight. September 12, three-fourths dead from early blight with a little mixture of late blight. September 19, foilage entirely dead, largely from early blight, but some late blight.

Polaris.—August 22, just in flower, leaves nearly half dead with early blight and tip burn. August 29, foliage two-thirds dead with early blight. September 5, leaves entirely dead, chiefly from early blight. September 12, tops entirely dead.

Early Rose.—August 22, green and healthy. September 5, still green, but considerable early blight. September 12, one-half of leaves dead from early blight, some indications of late blight. September 19, tops entirely dead.

Early Ohio.—August 22, yellow and dying. August 29, dying rapidly. September 5, nearly dead. September 12, all dead.

As soon as dug the potatoes were stored in a cool cellar in bushel boxes, stacked in such a way as to allow free circulation of air. The temperature of the storage cellar stood at 50 to 55° F., except during the early part of the period, when it occasionally reached 60° F. This occurred but seldom and for short periods. It probably did not rise above that figure.

Each lot was carefully sorted when dug and the weights of sound and decayed tubers recorded. On each date of digging all tubers previously dug and in storage were sorted, and the decayed ones weighed and removed. The entire lot was again sorted on November 5, nearly

six weeks after the first digging. The data thus secured is entered in the following table:

Variety	Date of digging	Total weight	Pounds decayed August 22	Pounds decayed August 29	Pounds decayed September 5	Pounds decayed September 12	Pounds decayed September 19	Pounds decayed September 26	Pounds decayed November 5	Total pounds decayed to November 5	Total pounds sound to November 5	Percent of decay on November 5
G. Mt.	Aug. 22	17.5	0	2	2	0	0	0.5	0.6	5.1	12.4	...
Del.	"	76.	0	6.3	2.3	1	1	0	0	8.5	67.5	...
R. N. Y.	"	120.	0	0	0	0	0	0	1.0	1.	119.	...
Polaris,	"	135.	0	0	0	0	0	0	3.5	3.5	131.5	...
E. Rose,	"	29.	0	0	0	0	0	0	0	0	29.	...
E. Ohio,	"	44.	0	0	0	0	0	0	0	0	44.	...
		421.5								18.1	403.4	4.3
G. Mt.	Aug. 29	27.5	..	0	3.5	6.5	0	0	0	10.	17.5	...
Del.	"	98.	..	0	12.0	2.0	0	0	1.5	15.5	82.5	...
R. N. Y.	"	158.5	..	0	7.5	5.5	0	0	0	13.	145.5	...
Polaris,	"	136.	..	0	2.0	0	0	0	8.5	10.5	125.5	...
E. Rose,	"	35.5	...	0	6.3	2.5	0	0	0.5	9.3	25.2	...
E. Ohio,	"	44.5	..	0	0	0.2	0	0	0.5	0.7	43.8	...
		500.								59.0	440.0	11.8
G. Mt.	Sept. 5	43.	..	..	0	0	0	[illegible]	2.0	2.	41.	...
Del.	"	141.	..	..	0	0	0	0.5	15.0	15.5	125.5	...
R. N. Y.	"	204.	..	..	0	0	0	0	93.0	93.	111.	...
Polaris,	"	137.	..	..	0	0	0	0	1.0	1.	136.	...
E. Rose,	"	49.	..	..	0	0	0	0	3.0	3.	46.	...
E. Ohio,	"	51.5	..	..	0	0	0	0	0.5	0.5	51.	...
		625.5								115.0	510.5	18.4
G. Mt.	Sept. 12	47.	..	..	..	0	0	0	0	0	47	...
Del.	"	153.	..	..	..	0	1	0.7	4.5	6.2	146.8	...
R. N. Y.	"	203.	..	..	..	0	4	2.5	29.0	35.5	167.5	...
Polaris,	"	156.	..	..	..	0	0	0	1.0	1.	155.	...
E. Rose,	"	51.	..	..	..	0	0	0	15.5	15.5	35.5	...
E. Ohio,	"	47.5	..	..	..	0	0	0	0	0	47.5	...
		657.5								58.2	599.3	8.9
G. Mt.	Sept. 19	53	..	..	..	..	0	0	0	0	53	...
Del.	"	148	..	..	..	..	3	2	0	5	143	...
R. N. Y.	"	200	..	..	..	..	10	14	16	40	160	...
Polaris,	"	134	..	..	..	..	0	0	2	2	132	...
E. Rose,	"	50	..	..	..	..	0	0	2	2	48	...
E. Ohio,	"	46	..	..	..	..	0	0	2	2	44	...
		631								51	578	8.0
G. Mt.	Sept. 26	44.	..	..	..	..	..	0	0	0	44.	...
Del.	"	172.	..	..	..	..	..	2	4	6	166.	..
R. N. Y.	"	184.	..	..	..	..	..	24	4	28	156.	...
Polaris,	"	167.	..	..	..	..	..	0	2	2	165.	...
E. Rose,	"	34.	..	..	..	..	..	0	1	1	33.	...
E. Ohio,	"	56.	..	..	..	..	..	0	2	2	54.	...
		657.								39	618.	6.0

DISCUSSION OF THE RESULTS

Owing to the peculiar weather conditions the progress of the late blight fungus on the foliage was at no time very conspicuous. Evidently, however, but slight infection of the tubers occurred before August 22, and there was little of practical moment after September 12. Nor was there much increase in the crop yield after this latter date.

The Early Ohio potatoes matured ahead of the fungus and there was practically no rot among them. With other varieties the rot was considerable, and the most of this occurred in the earlier dug tubers, i. e. the diggings of August 29 and September 5. The basis for this conclusion is seen clearly in the following figures drawn from the preceding tables, which give the average conditions existing on November 5 in the tubers dug at each date:

Date of digging	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26
Percent of rot	4.3	11.8	18.4	8.9	8.0	6.0
Pounds sound potatoes	403	440	510	599	578	618

It is worth while to recall in this connection the results of similar experimental diggings made last year, as follows:[1]

Date of digging	Aug. 31	Sept. 7	Sept. 14	Sept. 21	Sept. 28
Percent of rot	55.3	25.7	15.8	11.4	7.3
Pounds sound potatoes	84	150	169	175	171

The disease appeared somewhat earlier in 1903 and was more severe, but the trend of the results is the same. In both seasons much the greatest loss from rot occurred from the diggings of the last week of August and the first week of September—when the tops were still in vigorous condition and the tubers immature and probably but recently infected. There was much less loss where the digging was delayed till mid-September, when the vines as a whole were nearly dead and tuber growth practically completed. Somewhat less rot resulted on the average each season where the digging was delayed until about September 20, and a little less when it was postponed still one week later.

The results obtained in 1902 prompted the formulation of a tentative rule,[2] which was repeated with more confidence at the close of the trials of 1903, viz., "where there is danger of rot it is best to delay the digging for some ten days or more after the tops die and a longer delay does no harm."

[1] Vt. Sta. Rpt. 16, p. 162 (1903).

[2] Vt. Sta. Rpt. 15, p. 223 (1902).

The results of three successive seasons' work have shown this rule to be even safer as a generalization than was hoped when it was formulated. It may be now restated, slightly modified, as a safe rule for Vermont farm practice.

When potato tops have been killed by the late blight fungus and there is consequent danger of rot of the tubers, do not dig them until a week or more after the tops were killed. A longer delay will do no harm. With late varieties, where the progress of the disease is slow, do not begin digging until the third week of September at the earliest, and if practicable wait until after the tops are killed by frost.

III. DOES LIMING PREVENT ROT?

Results obtained last year[1] gave a negative answer to this question. It seemed best, however, to repeat the trial on a larger scale. Accordingly one-half of the yield from each variety dug on the first four dates, August 22, 29, September 5 and 12, in the experiment just discussed, was thoroughly sprinkled with air-slaked lime, about one-fourth pound being used to a bushel. These were stored under exactly the same conditions as were the unlimed tubers. The nature of the soil, sorting and condition of the foliage at each date of digging have been discussed on pages 391-392.

[1] Vt. Sta. Rpt. 16, p. 163 (1903).

The tabulated results follow:

Date	Sound tubers	Weight of tubers found decayed												Total to Nov. 5			
		Aug. 29		Sept. 5		Sept 12		Sept 19		Sept 26		Nov. 5		Decayed		Sound	
		Limed	Untr'd	Limed	Untr'd	Limed	Untr'd	Limed	Untr'd	Limed	Untr'd	Limed	Untr'd	Limed	Untr'd	Limed	Untr'd
GREEN MOUNTAIN																	
Aug. 22.....	8.7	0.7	...	1	...	0	...	0	...	0.5	...	0.5	...	....	....	.....	.....
" ".....	8.7	...	1.2	...	1	...	0	...	0	...	0	...	0.1	....	....	.....	.....
" 29.....	13.7	0	...	1.5	...	3	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	13.7	...	0	...	2	...	3.5	...	0	...	0	...	0	....	....	.....	.....
Sept. 5.....	21.5	...	...	0	...	0	...	0	...	0	...	1	...	....	....	.....	.....
" ".....	21.5	...	...	...	0	...	0	...	0	...	0	...	1	....	....	.....	.....
" 12.....	23.5	...	...	...	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	23.5	...	...	...	...	...	0	...	0	...	0	...	0	8.2	8.8	59.2	58.6
DELAWARE																	
Aug. 22.....	38.	2.7	...	0.7	....	0.4	...	0.5	...	0	...	0	...	....	....	.....	.....
" ".....	38.	...	3.5	...	1.5	...	0.6	...	0.5	...	0	...	0	....	....	.....	.....
" 29.....	49.	0	...	1.5	....	0.5	...	0	...	0	...	1	...	....	....	.....	.....
" ".....	49.	...	0	...	10.5	...	1.5	...	0	...	0	...	0.5	....	....	.....	.....
Sept. 5.....	70.5	...	...	0	....	0	...	0	...	0	...	5	...	....	....	.....	.....
" ".....	70.5	...	...	...	0	...	0	...	0	...	0.5	...	10	....	....	.....	.....
" 12.....	76.5	...	...	...	....	0	...	0	...	0	...	1.5	...	....	....	.....	.....
" ".....	76.5	...	...	...	....	...	0	...	1	...	0.7	...	3	13.9	33.8	220.1	200.2
RURAL NEW YORKER NO. 2																	
Aug. 22.....	60.	0	...	0	...	0	...	0	...	0	...	0.5	...	....	....	.....	.....
" ".....	60.	...	0	...	0	...	0	...	0	...	0	...	0.5	....	....	.....	.....
Aug. 29.....	79.2	0	...	3	...	3	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	79.2	...	0	...	4.5	...	2.5	...	0	...	0	...	0	....	....	.....	.....
Sept. 5.....	102.	...	...	0	...	0	...	0	...	0	...	50	...	....	....	.....	.....
" ".....	102.	...	...	...	0	...	0	...	0	...	0	...	43	....	....	.....	.....
" 12.....	101.5	...	...	...	...	0	...	2	...	0	...	18	...	....	....	.....	.....
" ".....	101.5	...	...	...	...	...	0	...	2	...	2.5	...	11	76.5	66	266.2	276.7
POLARIS																	
Aug. 22.....	62.5	0	...	0	...	0	...	0	...	0	...	1	...	....	....	.....	.....
" ".....	62.5	...	0	...	0	...	0	...	0	...	0	...	2.5	....	....	.....	.....
" 29.....	68.	0	...	2	...	0	...	0	...	0	...	5.5	...	....	....	.....	.....
" ".....	68.	...	0	...	0	...	0	...	0	...	0	...	3	....	....	.....	.....
Sept. 5.....	68.5	...	...	0	...	0	...	0	...	0	...	0.5	...	....	....	.....	.....
" ".....	68.5	...	...	...	0	...	0	...	0	...	0	...	0.5	....	....	.....	.....
" 12.....	78.	...	...	...	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	78.	...	...	...	...	...	0	...	0	...	0	...	1	9.0	7.0	273.0	275.0
EARLY ROSE																	
Aug. 22.....	14.5	0	...	0	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	14.5	...	0	...	0	...	0	...	0	...	0	...	0	....	....	.....	.....
" 29.....	17.7	0	...	1.7	...	1	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	17.7	...	0	...	4.5	...	1.5	...	0	...	0	...	0.5	....	....	.....	.....
Sept. 5.....	24.5	...	...	0	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	24.5	...	...	...	0	...	0	...	0	...	0	...	3	....	....	.....	.....
" 12.....	25.5	...	...	...	...	0	...	0	...	0	...	8	...	....	....	.....	.....
" ".....	25.5	...	...	...	...	...	0	...	0	...	0	...	7.5	10.7	17.0	71.5	65.2
EARLY OHIO																	
Aug. 22.....	22.	0	...	0	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	22.	...	0	...	0	...	0	...	0	...	0	...	0	....	....	.....	.....
" 29.....	22.2	0	...	0	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	22.2	...	0	...	0	...	0.2	...	0	...	0	...	0.5	....	....	.....	.....
Sept. 5.....	25.7	...	...	0	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	25.7	...	...	...	0	...	0	...	0	...	0	...	0.5	....	....	.....	.....
" 12.....	23.7	...	...	...	...	0	...	0	...	0	...	0	...	....	....	.....	.....
" ".....	23.7	...	...	...	...	...	0	...	0	...	0	...	0	0	1.2	93.7	92.5

The results may be summarized as follows:

Variety		Limed	Unlimed	Gain or loss
Green Mountain......	total decay...	12 percent	13 percent	+1 percent
Delaware..............	" " ...	6 "	14 "	+8 "
Rural New Yorker...	" " ...	22 "	19 "	−3 "
Polaris................	" " ...	3 "	2 "	−1 "
Early Rose............	" " ...	13 "	20 "	+7 "
Early Ohio............	" " ...	0 "	1 "	+1 "
Averages..........	" " ...	9 "	11 "	+2 "

There was therefore a slight gain on the average from the use of lime. These results may well be compared with those obtained last year, when there was slightly more rot in the limed potatoes, viz., 29 percent in those limed as compared with 27 percent in the unlimed. This year four out of the six showed rot where limed, last year three out of four showed less rot where not limed. These differences, taking the average of the two seasons, exactly neutralize each other. The results of the two years' trials therefore lead us to doubt the practical value of liming potatoes.[1]

IV. DISINFECTION OF SCABBY POTATOES BY FORMALDEHYDE GAS

Soaking seed potatoes in either corrosive sublimate or formalin solution is the standard method of disinfection and is commended for ordinary farm practice. It is, however, a laborious process for the large grower and seed dealer who handles large quantities of seed in storage bins. Hence trials were begun some years ago[2] in which large quantities of seed were treated with the fumes of gaseous disinfectants. Sulphur fumes were tested and proved valueless, but formaldehyde (formalin) gas promised so well that its trial has been continued through several seasons and its efficacy apparently demonstrated.

The trials made in 1904 were located on land adjoining that hitherto used for similar experiments, being recently cleared pine land not previously sown to cultivated crops. New land has been broken up each year which, no doubt, is entirely free from contamination.

The seed was selected from crops grown on the scab plots of 1903, two varieties, Delaware and Rural New Yorker No. 2 being used.

[1] The Market Growers' Gazette (London), Dec. 14, 1904. p. 427, after the above was written, published results of two years' trials of liming, made under the direction of H. Hunter, of the Department of Agriculture of Ireland. So far as can be gathered from the brief summary there given the results in general showed no benefit from liming. The only exception was in one lot where a large amount of potatoes showing soft rot were mixed with the sound ones at the beginning of the experiment. In this case the use of lime checked the spread of the rot.

[2] Vt. Sta. Rpts. 13, p. 273 (1900); 14, p. 231 (1901); 15, p. 227-230 (1902); 16, p. 165 (1903).

In each case the seed was divided into two classes, "smooth" and "scabby," as has been done in previous trials. The latter were badly scabbed tubers, while the former showed no visible signs of the disease, though sorted from the same lots as the scabby seed. Doubtless both lots carried the germs of the scab on the surface, although the results show that the disease developed much worse from the scabby seed.

This seed was planted in eight plots as described below, each plot comprising four rows 75 feet long and requiring one-half bushel of seed. The experimental plots were separated in each case by non-experimental check rows of another variety which had previously been disinfected with formalin solution.

Four methods of disinfection were compared as follows:

First—Seed soaked two hours in a solution of 8 ounces formalin in 15 gallons water; standard method; used as a basis of comparison (Plot I).

Second—Formalin vapor; seed dry and uncleaned, i. e. just as they came from the bin; 25 c. c. formalin (Plot II); 12.5 c. c. (Plot V).

Third—Formalin vapor; seed soaked one-half hour in water before treatment and placed in disinfecting box while wet; 25 c. c. formalin (Plot III); 12.5 c. c. (Plot VI).

Fourth—Formalin vapor; seed thoroughly washed in water and allowed to dry before placed in disinfecting box; 25 c. c. formalin (Plot IV); 12.5 c. c. (Plot VII).

The seed planted on Plot VIII was left untreated.

Merck's formalin (40 percent formaldehyde) was used in all cases. The potatoes to be treated with formalin vapor (30 pounds in each lot) were enclosed in a box containing 8.2 cubic feet, capable of being tightly closed. The method of vaporizing the formalin was somewhat modified from that heretofore used.[1] The desired amount of

[1] The details of the method here employed were suggested by the Station chemist. Those hitherto used—boiling in closed glass flask (1900) and in a coil of gaspipe (1903) were open to serious objection of breakage and loss through chemical changes caused by high temperatures operating in closed receptacles. Accordingly the method of generating the vapor was modified as follows: The required amount of formalin solution was diluted to 100 c. c., placed in a rubber stoppered flask, tubes being fitted therein, one opening just belo wthe cork and connected by rubber tubing with the disinfecting box, the other extending to the bottom of the flask and opening below the surface of the fluid, and connected by rubber tubing with a steam generator. As soon as the diluted formalin reached boiling a stream current was turned on from the generator. A thermometer inserted in the top of the box enabled one to avoid overheating with the steam current, which was also guarded against by the use of a long conveying tube. The steam and the flame under the flask were so regulated that the liquid was kept at any desired level. This procedure was carried on for one hour. While the current of steam was passing through the liquid all of the time it was so regulated that the volume of the liquid was reduced one-half and then restored to original volume by condensation of the flowing steam several times. At the close of the hour the steam was cut off and the contents of the flask slowly boiled down to 10 or 15 cubic centimeters.

formalin (either 12.5 or 25 c. c.) was diluted with 100 c. c. of water, then placed in a flask, connected with the disinfecting box by a tube and distilled slowly, the vaporized water being continuously replenished, so that at the end of an hour one-half the volume still remained. This was then boiled to about one-tenth the original volume, which served to vaporize practically all the formalin. A thermometer in the box showed that the temperature remained below 80° F. during this process. After its close the box was left shut for 24 hours. When opened at the end of this period a strong odor of formalin was evident. All disinfecting was performed within twenty-four to forty-eight hours before planting, and the seed after disinfection was placed in new, clean paper sacks.

The disinfections were made on May 10 and 11, and, on May 12, the potatoes were planted, commercial fertilizer being used. The plants were unsprayed save with paris green. Potatoes grown on the sandy soils near Burlington are particularly susceptible to early blight, and this disease killed the tops upon these scab plots before the first of September. The tubers were left undug, however, until frost threatened in order to give the scab the fullest opportunity to develop. They were dug on October 28 and were sorted as soon thereafter as possible.

The detailed results are given in the accompanying table:[1]

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[1] On account of lack of scabby seed of Rural New Yorker No. 2, smooth Delaware and Rural New Yorker No. 2 seed, disinfected with formalin solution, was placed in the last row of each of plots V-VII; consequently only the data afforded by smooth and scabby Delaware rows are considered in the summary for these plots.

Plot and variety	Condition of seed	Treatment	Total weight of tubers	Smooth		Scabby		
				Weight	Number	Weight	Number	Percent (by number)
			lbs.	lbs.	lbs.	lbs.	lbs.	
PLOT I								
Delaware,	Scabby	Formalin Sol.	35.	33.3	387	1.7	13	3.3
"	Smooth	" "	58.2	57.9	387	0.3	3	0.8
R. N. Y. 2	Smooth	" "	60.	59.2	465	0.8	5	1.1
"	Scabby	" "	50.	47.6	420	2.4	19	4.3
PLOT II								
Delaware,	Scabby	For. vapor 25 cc seed dry	54.	53.9	475	0.1	1	0.2
"	Smooth	" "	60.	59.4	534	0.6	6	1.1
R. N. Y. 2	Smooth	" "	61.	60.7	430	0.3	2	0.5
"	Scabby	" "	47.	47.0	361	0.0	0	0
PLOT III								
Delaware,	Scabby	For. vapor 25 cc seed wet	49.	48.4	412	0.6	6	1.4
"	Smooth	" "	43.	43.	359	0.0	0	0
R. N. Y. 2	Smooth	" "	50.8	50.6	347	0.2	2	0.6
"	Scabby	" "	49.0	48.3	312	0.7	8	2.5
PLOT IV								
Delaware,	Scabby	For. vapor 25 cc seed scrubbed	42.8	41.9	367	0.9	4	1.1
"	Smooth	" "	42.0	42.0	328	0.0	0	0
R. N. Y. 2	Smooth	" "	45.5	45.1	316	0.4	3	0.9
"	Scabby	" "	31.5	31.0	251	0.5	3	1.2
PLOT V								
Delaware,	Scabby	For. vapor 12½ cc seed dry	48.	47.4	402	0.6	9	2.2
"	Smooth	" "	45.	43.5	440	1.5	15	3.3
R. N. Y. 2	Smooth	" "	64.	63.9	499	0.1	1	0.2
Delaware.	Smooth	Formalin sol.	61.	60.9	437	0.1	1	0.2
PLOT VI								
Delaware.	Scabby	For. vapor 12½ cc seed wet	36.	34.2	331	1.8	12	3.5
"	Smooth	" "	37.	35.5	375	1.5	12	3.1
R. N. Y. 2	Smooth	" "	54.	52.1	442	1.9	17	3.7
"	Smooth	Formalin sol.	40.	39.0	377	1.0	7	1.8
PLOT VII								
Delaware,	Scabby	For. vapor 12½ cc seed scrubbed	46.	44.5	477	1.5	18	3.6
"	Smooth	" "	56.	56.0	523	0.0	0	0
R. N. Y. 2	Smooth	" "	67.	66.5	537	0.5	2	0.4
Delaware,	Smooth	Formalin sol.	47.8	47.3	558	0.5	6	1.1
PLOT VIII								
Delaware,	Scabby	Untreated	41.8	31.8	333	10.0	101	23.3
"	Smooth	"	58.5	57.7	556	0.8	4	0.7
R. N. Y. 2	Smooth	"	65.	64.8	637	0.2	4	0.6
"	Scabby	"	59.6	46.9	385	12.7	95	19.8

The most significant data which the last table presents are more easily compared when reduced to the following form. They show the percentages (by number, not weight) of scabby tubers resulting from the various treatments:

Character of seed	Not disinfected	Formalin solution	25 c. c. formalin vaporized			12½ c. c. formalin vaporized		
			Seed dry	Seed scrubbed	Seed wet	Seed dry	Seed scrubbed	Seed wet
Delaware								
Scabby seed	23.3	3.3	0.2	1.1	1.4	2.2	3.6	3.5
Smooth seed	0.7	0.8	1.1	0.0	0.0	3.3	0.0	3.1
Rural New Yorker								
Scabby seed	19.8	4.3	0.0	1.2	2.5	...	...	...
Smooth seed	0.6	1.1	0.5	0.9	0.6	...	...	...
Averages from								
Smooth seed	0.7	1.0	0.8	0.5	0.3	3.3	0.	3.1
Scabby seed	21.6	3.8	0.1	1.1	2.0	2.2	3.6	3.5

DISCUSSION OF THE RESULTS

As in all previous trials, minor irregularities occur. These may, of course, be due to accidental infection in the field; in any case they prevent exact comparisons or conclusions. Nevertheless the evidence is unmistakable as to the general outcome. Clearly the results from the smooth seed are to be disregarded since there is but little scab anywhere, and no more in the rows where no disinfection was practiced than on the average in the treated rows. There can be no question, however, as to the reduction of disease by disinfection where scabby seed was used. It is likewise evident that the gaseous treatment is fully as effective as the standard method of soaking in formalin solution. Moreover, the conclusion seems inevitable that the gaseous treatment was *more effective on the dry seed* than upon that which was wet. This feature in the outcome was not what we expected, but we are forced to accept it since the results are in full accord with those obtained in the trials made in 1903,[1] reproduced here for convenience of comparison.

		Not disinfected	Formalin solution	Formalin vapor seed dry	Formalin vapor seed wet
Delaware..........	Scabby	24.2	2.2	2.4	15.0
"	Smooth	3.1	0.2	0.2	7.1
Rural New Yorker..	Scabby	24.5	1.0	1.5	8.5
"	Smooth	4.1	0.9	0.2	2.3

The logical inference seems to be that the layer of moisture upon the surface of the tubers does not readily absorb the formalin gas; hence the latter is prevented from full action upon the germs. As already explained, the distillation method used this year is an improvement over that previously used, to which may be attributed the greater effectiveness of the 1904 treatment, especially on the wet seed.

[1] Vt. Sta. Rpt. 16, p. 167 (1903).

The outcome of the present trials, so far as it goes, indicates better results from the distillation of the larger amount of formalin, although the results from the smaller amount seem fully equal to those from soaking in the formalin solution. In the light of these trials we suggest the use of larger quantities than heretofore advised, viz., three pounds (three pints) of formalin for each 1,000 cubic feet of storage room to be disinfected. This should be diluted before distillation with not less than four times its volume of water, and it would probably be better to use twice this amount. The disinfecting chamber should be made as tight as possible, the smaller and the tighter the better. Place the formalin solution in one or more kettles or pans over a kerosene or other stove in the middle of the room, supplied with fuel enough to evaporate the water nearly or quite fully; retire from the room, close it tightly and leave it closed for twenty-four hours or longer.[1]

AN INSPECTION OF GRASS AND CLOVER SEED.

Vermont is pre-eminently a grass growing State. Its farmers pay more money for grass and clover seeds than for all other kinds. Formerly these were grown in New England; now they are mostly supplied from Chicago and other more Western markets. Eastern farmers have come to believe that in many cases the quality of this seed is inferior and to attribute failure to secure a stand or weediness of the newly seeded fields to such inferiority. To add to the information on this point this Station has at one time and another[2] published the results of such examinations as it has made into the conditions of the seed trade of Vermont. During the past year a much more painstaking investigation was undertaken in response to a request expressed in a joint resolution of the General Assembly of 1902, reading as follows:

Resolved by the Senate and House of Representatives:

That the Vermont Agricultural Experiment Station be and hereby is requested to study the condition of the trade in this State in grass and other agricultural seeds with a view of recommending to the next

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[1] Just as this matter is going to press a more convenient method of generating formaldehyde gas which may prove equally effective is brought to our attention. Evans & Russell (Bul. Maine Lab. of Hygiene, 1904) propose that formalin be added to powdered potassium permanganate in the proportion of a pint to 6.5 ounces. They state that 69 percent of the gas is made available in five minutes and that an 81 percent yield is eventually obtained. This method of formalin gas generation will be tested during the coming season as to its adaptation in tuber disinfection.

[2] Vt. Sta. Rpt. 13, p. 287 (1900).

General Assembly some measure looking towards the attainment of a purer seed supply.

JOHN H. MERRIFIELD,
Speaker of the House of Representatives.
ZED S. STANTON,
President of the Senate.

Approved November 20, 1902.
JOHN G. McCULLOUGH, Governor.

In compliance with this resolution the Station undertook to secure samples representative of the grass and clover seeds offered in the Vermont markets in the spring of 1903. Samples representing 735 lots of seeds were obtained of dealers in all parts of the State, including:

	Samples.		Samples.
Timothy	222	Red clover (mammoth)	30
Red-top	83	Alsike clover	105
Kentucky blue grass	8	White clover	14
Orchard-grass	11	Crimson clover	4
Meadow fescue	1	Alfalfa	10
Hungarian and various millets	103	Rape	1
Red clover (common)	134	Lawn grass mixtures	9
			735

These seeds were examined with results as outlined herewith and a report was filed with the General Assembly of 1904 early in November. The sampling agents were the men primarily employed in collecting samples of commercial fertilizers, and were instructed to secure representative samples of as many of the lots of grass and clover seed offered for sale as were obtainable. They were further instructed to state to dealers the object in view, to buy and pay for the seed obtained, to discover the source of the seed whenever practicable and its price per pound, to assure the local dealers that no use would be made of their names in publication when inferior seed was discovered, to use due care to make the samples thoroughly representative of the lots and to ship them promptly to the Station in sealed envelope packages.

Inasmuch as this Station did not have the facilities for handling so large a number of seed samples expeditiously, advantage was taken of a generous offer from the Seed Laboratory of the Bureau of Plant Industry, United States Department of Agriculture, to carry on the work in co-operation. It was agreed that the Station should secure the samples and information concerning them, that the Department should make the examinations of seeds as to purity and germination,

and that both institutions should be free to publish the results. The bulk of the exacting work fell upon the department officials, to whom our thanks are due. The Station is particularly indebted to Mr. Edgar Brown, botanist in charge of the Seed Laboratory, for the tabulated results with comments, which form the basis of this discussion.

Since this investigation constitutes one of the most exhaustive systematic examinations ever made into the grass seed conditions of any State, the results are printed in detail as a matter of record. These tabulated details, given in the appendix, are worthy of careful examination by any one especially interested in such matters. The more important facts and conclusions are brought together under the following heads:

RED CLOVER (common red or medium. *Trifolium pratense*)

The standards of purity and germination as recommended for first class seed by the U. S. Department of Agriculture are: Purity, 98 percent; germination, 85-90 percent.[1]

One hundred and thirty-four samples of this seed were secured. Their average purity proved to be 91 percent, and average germination, 87 percent. They ranged much below the United States standard in purity, but just about met it in germination. Examinations of the tables show that only twelve samples, or 9 percent of the whole, met the standard as to purity, whereas 122 or 91 percent were below it. With reference to germination 102 samples, or 76 percent, were up to standard, and the balance, 32 samples or 24 percent, were below.

The condition of these seeds as to purity is, therefore, decidedly unsatisfactory. A considerable number carried from 5 to 15 percent of foreign seeds. In many cases this was largely timothy, but in some samples there was a large amount of weed seeds. The worst indictment is that one sample, No. 19,016, shows evident adulteration, since it contains 49 percent of foreign seed, principally yellow trefoil.[2]

The Department states that this a common adulterant of red clover and alfalfa seed. Other cases of its use will be cited under

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[1] "The term *purity*, the percentage of which is reckoned by weight, denotes freedom from foreign matter such as chaff, dirt or seeds of other plants. The percentage of *germination* is reckoned by count from a sample freed from foreign matter, a seed being counted germinated when the rootlet or radicle has pushed through the seed coat."—U. S. Dept. Agr. Year-book of 1896, p. 623.

The above "standards" have no legal status but simply form an expression of expert opinion as to what should be the condition of good commercial seed.

The germination tests reported upon here were based upon trials conducted by the standard methods of the Department.

[2] Yellow trefoil, also called black medic (*Medicago lupulina*) is an annual plant of the clover family with low spreading stems and small yellow clover-like blossom. It is not an objectionable plant in meadow or pasture, except in so far as it occupies the place of better clovers.

mammoth clover and alfalfa. Yellow trefoil seed is imported from Europe, principally for purposes of adulteration. It is significant in this connection that the three samples showing such adulteration all came from one retailer, who stated to our sampling agent that they were purchased by him from a wholesale house in New York, a firm which, according to advice from the Department, is a large importer of yellow trefoil and for many years has used it as an adulterant. Attention will be directed later to the attempt in Kentucky to legislate directly against such adulteration.

The germination tests gave better results on the whole. It should be noted, however, that several showed so low germination as to justify the conclusion that they were old seed. One sample, No. 18,748, was practically lifeless, showing less than 1 percent germination. A dealer who knowingly sells old, dead clover seed deserves censure. Clover seed, if kept beyond one year, even under good conditions, is liable to lose somewhat in vitality. Old seed should never be used or offered for sale without carefully testing it beforehand.

MAMMOTH RED CLOVER. (*Trifolium pratense var.*)

United States standards.—Purity, 98 percent; germination, 85-90 percent.

Averages found in 50 samples examined.—Purity, 90 percent; germination, 85 percent.

Percent of samples meeting U. S. standards of purity..............	2
Percent of samples below U. S. standards of purity..............	98
Percent of samples meeting U. S. standards of germination........	88
Percent of samples below U. S. standards of germination........	12

On the face of the returns the mammoth clover seed appears rather poorer than does the common red. As a matter of fact, however, the impurities were mostly alsike and timothy seed mixed with a comparatively small amount of weed seeds. The presence of the alsike indicates that the seed is of Canadian origin. One sample, No. 19,000, contained about 46 percent of foreign seed, principally yellow trefoil, evidently added as an adulterant. This came from the same source as red clover No. 19,018, and the comments already made regarding that sample apply to this as well.

An important fact not shown in such examinations as are here reported is that much of the clover seed offered on the markets as "Mammoth" is really the common red variety. The Rhode Island Station[1] found that of eight samples secured from as many leading seed

[1] R. I. Sta. Rpt. 17, p. 202 (1904).

houses only four were true to name. This shows a surprising condition, when it is remembered that both varieties are American grown and that the two are offered at practically the same price.

ALSIKE CLOVER. (*Trifolium hybridum.*)

United States standards.—Purity, 95 percent; germination, 75-80 percent.

Averages found in 105 samples examined.—Purity, 85 percent; germination, 77 percent.

Percent of samples meeting U. S. standards of purity	10
Percent of samples below U. S. standards of purity	90
Percent of samples meeting U. S. standards of germination	73
Percent of samples below U. S. standards of germination	27

Here, again, the figures look somewhat worse than were the actual conditions. A number of the samples contain 10 percent or more of foreign seeds. In most cases this is largely timothy seed mixed with a smaller percent of weed seeds. A few samples contain some white clover seed. The bulk of the foreign seeds in samples No. 19,066 and No. 19,184 is, however, sheep sorrel (*Rumex acetosella*), which we have found in all previous examinations to be of common occurrence in alsike clover seed.

WHITE CLOVER. (*Trifolium repens*)

United States standards.—Purity, 95 percent; germination, 75-80 percent.

Average conditions found in 14 samples examined.—Purity, 86 percent; germination, 59 percent.

Percent of samples meeting U. S. standard of purity	0
Percent of samples below U. S. standard of purity	100
Percent of samples meeting U. S. standards of germination	43
Percent of samples below U. S. standards of germination	57

Four of the 14 samples showed over 12 percent of foreign seeds. Although there were weed seeds among these, the bulk of the impurity cannot be so rated in any of these cases, since in one it consisted of alsike, in another of red clover, in another of timothy and in the other of rabbit's foot clover. These foreign seeds are all seriously objectionable in lawn seeding, but not for pasture. In the latter case it is to be considered, however, that the foreign seed is a cheaper one than the white clover.

CRIMSON CLOVER. (*Trifolium incarnatum*)

United States standards.—Purity, 98 percent; germination, 85-90 percent.

Averages found in 4 samples examined.—Purity, 96 percent; germination, 12 percent.

Since this clover is not a success agriculturally in Vermont, the conditions do not concern the matter in hand further than to show that more care must be exercised in order to secure good seed of the less used plants like this than of the standard ones.

ALFALFA. (*Medicago sativa*)

United States standards.—Purity, 98 percent; germination, 85-90 percent.

Averages found in 10 samples examined—Purity, 91 percent; germination, 79 percent.

Percent of samples meeting U. S. standard of purity.............. 10
Percent of samples below U. S. standard of purity.............. 90
Percent of samples meeting U. S. standards of germination........ 30
Percent of samples below U. S. standards of germination........ 70

The generally inferior character of this seed is noteworthy; but more so is the occurrence of one sample out of the ten (No. 18,981), containing nearly 14 percent of foreign seed, of which the bulk is yellow trefoil. This is doubtless an adulterant, as explained in the discussion of the similar adulteration of red clover.

TIMOTHY. (*Phleum pratense*)

United States standards.—Purity, 98 percent; germination, 85-90 percent.

Averages found in 222 samples examined.—Purity, 98 percent; germination, 88 percent.

Percent of samples meeting U. S. standard of purity.............. 68
Percent of samples below U. S. standard of purity.............. 32
Percent of samples meeting U. S. standard of germination........ 77
Percent of samples below U. S. standard of germination........ 23

These results show the cleanest and best seed of any kind examined and do not call for special comment. As a rule those Vermont farmers who buy high grade goods have little reason for fault-finding with the quality of timothy seed.

RED TOP. (*Agrostis alba*)

The lack of uniformity in methods of cleaning and handling this seed has deterred the seed experts of the Department from fixing upon standards. The examination of the 83 samples secured show averages as follows: Purity, 80 percent; germination, 87 percent. This reveals a fairly satisfactory condition when one considers that much of the

impurity is harmless. Nevertheless, there would be a decided gain could every purchaser understand clearly the difference between the chaffy seed and the recleaned seeds of this grass, i. e. have more definite assurance as to when he is buying chaff and when seed.

The chaffy scales cling to red-top seed more closely than to timothy, and, as a result, red-top was formerly sold "in the chaff," that is, with chaff still clinging to or mixed with the seed; and it was difficult to judge from appearance how much good seed a sample contained. Methods have been perfected of late for cleaning the looser chaff from the seed in a very satisfactory manner, and all seedsmen can and should offer this "recleaned" seed. In general, one pound of such seed contains as much seed as does four pounds "in the chaff"; and the price is accordingly four times as high. No one should hesitate, however, to buy the recleaned seed at the higher price and to use a proportionately smaller quantity in seeding. The only difficulty is in being sure that one secures a high grade recleaned seed when he pays for it.

KENTUCKY BLUE GRASS. (*Poa pratensis*)

United States standards.—Purity, 90 percent; germination, 45-50 percent.

Averages found in 8 samples examined.—Purity, 63 percent; germination, 55 percent.

This showing leaves much to be desired as to purity. It is to be noted, however, that except in two cases the impurity was inert matter (chaff, etc.), some of which must be tolerated in all cases except the cleanest of such "chaffy seeds" as this. The other two cases deserve especial notice (Nos. 18,842 and 18,908). In both, the bulk of the seed is that of the Canadian blue grass (*Poa compressa*). Canadian blue grass seed is said to be the common adulterant of Kentucky blue grass, the price usually being about one-half of the latter. During the twelve months ending June 30, 1904, three-quarters of a million pounds of this seed was imported into the United States from Canada, practically all for the purpose of adulterating Kentucky blue grass seed. This state of affairs has led to the passage in Kentucky of a special law against this adulteration. (See page 415).

ORCHARD GRASS. (*Dactylis glomerata*)

United States standards.—Purity, 90 percent; germination, not yet fixed.

Averages found in 11 samples examined.—Purity, 55 percent; germination, 56 percent.

None of the samples reached the U. S. standard of purity. Here again it is to be noted that we are dealing with a chaffy seed and that the bulk of the impurity is inert matter (chaff, etc). Over one-half of the samples contain a large percent (13 to 26%) of foreign seed, which, however, is mostly that of meadow fescue. This is a good grass, but the seed costs only about one-half the price of orchard grass, and so closely resembles it that it is commonly used as an adulterant. Undoubtedly that is the case here. These adulterations are practiced by the wholesaler rather than the retailer, as is evidenced by the fact that one-half of these adulterated seeds (Nos. 18,266, 18,967, 19,055) came from one wholesale firm and the balance (Nos. 19,127, 19,233, 19,334) from another wholesaler.

The averages obtained with other seeds appear below without further comment:

RAPE. (*Brassica napus*)

U. S. standards.—Purity, 99 percent; germination, 90-95 percent.

Found in one Vermont sample.—Purity, 94 percent; germination, 98.5 percent.

MEADOW FESCUE. (*Festuca pratensis*)

U. S. standards.—Purity, 95 percent; germination, 85-90 percent.

Found in one Vermont sample.—Purity, 92 percent; germination, 46 percent.

MILLETS. (Various kinds)

U. S. standards.—Purity, 99 percent; germination, 85-90 percent.

Found in 103 Vermont samples.—Purity, 96 percent; germination, 90 percent.

LAWN GRASS MIXTURES

Nine samples show their average content of pure grass and clover seeds to be 86 percent. Lawn grass mixtures are little used in Vermont. It is well that this is so, for they are sold at extra prices and are of inferior quality. To make the best lawn in this State a mixture should be made of timothy, Kentucky blue grass and white clover. In wet soil, red-top may replace the blue grass. Several of these lawn grass mixtures contained coarse grasses and clovers which form unsightly bunches in the lawn, and are as objectionable as weed seed.

Discussion of the Results

The results here presented reveal a condition as to the seed supply of the State which is far from satisfactory. The chief evils found to exist are of four classes;

First.—*A considerable amount of inert foreign matter, dirt, chaff, etc.*, in certain classes of seeds. Little occurs in the seeds most used, i. e. timothy, red and alsike clovers, but it is more abundant in the less used and "chaffy" grasses. It does no harm except lessening somewhat the value actually secured for the price paid. The intelligent buyer who will select and pay for the best class of seeds offered rarely meets this difficulty. It is, therefore, less serious than the evils of the second and third classes which follow.

Second.—*The occurrence of weed seeds.* The limitations of the present tabulation prevent the presentation of these in detail. The results of similar examinations of previous years were presented and discussed in a former report.[1] The results of the present inquiry are in general accord with our earlier ones and show the correctness of the general opinion of farmers that clover seed is a prolific source of weeds.

"Two of the clover samples [1900 inspection] contain weed seeds at the rate respectively of 19,500 and 21,200 to the pound, while eighteen of those samples showing greatest impurity average to contain 13,000 weed seeds to the pound. Of the seeds represented above, green foxtail, pigweed, red-stem plantain (*P. Rugellii*), smartweed, English plantain, sheep sorrel and curled dock are of the most common occurrence. Of these the plantain and the sheep sorrel are the most injurious to the farmer. A pound of sample No. 49 would contain over 16,000 seeds of red-stem plantain."[2]

It certainly behooves purchasers to secure only high grade clover seed as free from weed seeds as is obtainable. On the other hand it should be borne in mind, in justice to the seed trade, that there are weed seeds enough in the average soil to give an abundant growth. Not infrequently when the soil or weather conditions are unfavorable and clover makes a poor growth it is the weed seeds from the soil that crowd it out rather than those which are introduced with the seed. Comparatively few cases have come under our observation where there were enough weed seeds in clover seeds to cause a failure to secure a fair stand. Probably the average farmer attributes a larger proportion that he should of the weeds in his newly seeded crop to foul clover seed and too small a percent to seed lying in the soil.

Third.—*The occurrence of foreign seeds of various kinds having more or less agricultural value*, and therefore, not strictly to be rated as "weeds." These should be subdivided into two classes:

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[1] Vt. Sta. Rpt. 13, p. 287 (1900).

[2] Loc. cit. p. 297.

(1.) Seeds of plants which grow commonly in mixture with the plant in question, and which must, therefore, be expected to be present in some amount in all except the purest grades of such seeds. These may in a sense be regarded as legitimate impurities, unless in too large amounts, e. g. timothy seed in mixture with alsike clover; alsike clover in mixture with red clover; timothy in mixture with redtop. The only practical objection to this class of impurities as the seeds are used in Vermont farm practice arises when the impurity is the cheaper of the two seeds. This is, therefore, a matter of minor consequence.

(2.) There is a second class of seeds, however, which are of plants not growing in natural mixture with the plants in question and whose presence is evidence of deliberate adulteration. The flagrant cases of this character were the mixtures of yellow trefoil[1] with the red clovers and alfalfa, of meadow fescue with orchard grass, of Canadian blue grass with Kentucky blue grass. These have already been commented upon under their respective heads. We will only emphasize that this constitutes, in our judgment, the strongest argument for legislation that has developed from our investigations.

Fourth.—*The low germination shown in numerous cases.* This again is of two classes:

(1.) Moderately low, such as is legitimately to be expected in the cheaper and low grades of seeds. This is a serious matter in practically all grass and clover seeds except timothy. It is, however, largely within the power of the intelligent purchaser to protect himself, so far as he chooses to do, by securing the higher grades of seeds and making germination tests as indicated below.

(2.) Very low, evidently due to the seed being old. The sample of red clover seed No. 18,748, of which only three-fourths of a percent grew, is of this class. Such cases are, however, rare, and the intelligent purchaser can protect himself by germination tests, as described later.

RECOMMENDATIONS LOOKING TO THE BETTERMENT OF CONDITIONS

It is evident from the facts set forth that there is offered in Vermont some good grass and clover seed along with much that is of an inferior grade, a little that is almost worthless and occasionally some which is adulterated. What can be done to better conditions? Two courses are open: first, more careful seed inspection; second, legislation, which may of course involve inspection also.

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[1] *Medicago lupulina,* also called black medic.

SEED INSPECTION

This Station in the past has always made careful examinations as to purity of all samples of seeds sent it and expects to continue to do so. The Seed Laboratory of the National Department of Agriculture makes similar examinations and, also, germination tests for all who ask it. Unquestionably there would be decided advantage to purchasers if they sent more samples to the Station or to the Department for examination before purchase. When this is done at least a week or ten days must be allowed for the report upon purity, and longer, of course, for that upon germination.[1]

Any painstaking person, however, can form a sufficiently accurate judgment for his practical guidance by home examination. A magnifying glass like that here figured costs but fifty cents, and with it the amount and general nature of the impurities in a sample of grass seed is readily seen. A more critical examination and some experience is, of course, necessary to identify the various weed seeds which may occur.

For making determinations as to whether or not the seed has a good degree of vitality it will suffice for most practical purposes to make home tests as follows:[2]

For testing seeds at home the simpler the method the better, providing it supplies good conditions for germination. These conditions are: temperature, about 60-70°, i. e. that of the average living room; little or no light; constant moisture but never full immersion in water. Either of the following methods serve admirably:

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[1] It frequently happens that a large number of samples are sent in only a few weeks or days before sowing time. On this account it may take a longer time than that mentioned above before the final report on all can be made. To avoid difficulties of this kind purchasers and dealers are requested to send samples as early in the season as possible.

Samples should represent the entire lot as a whole. Small quantities of not more than five bushels should be emptied on a clean floor, thoroughly mixed, and a small quantity of seed taken from different parts of the pile to make up the sample sent. When seed in a bin is to be sampled, portions should be taken from various parts, both top and bottom, mixed thoroughly, and the sample for testing taken from this lot. When seed in sacks in large quantities is to be sampled a small portion should be taken from each bag (best from different parts of the bag by means of a seed sampler) and all thoroughly mixed and the sample taken as before. At least one ounce of each kind of seed should be sent.

[2] These methods are substantially those recommended by A. J. Pieters, U. S. Dept. Agr. Year-book for 1895, p. 182.

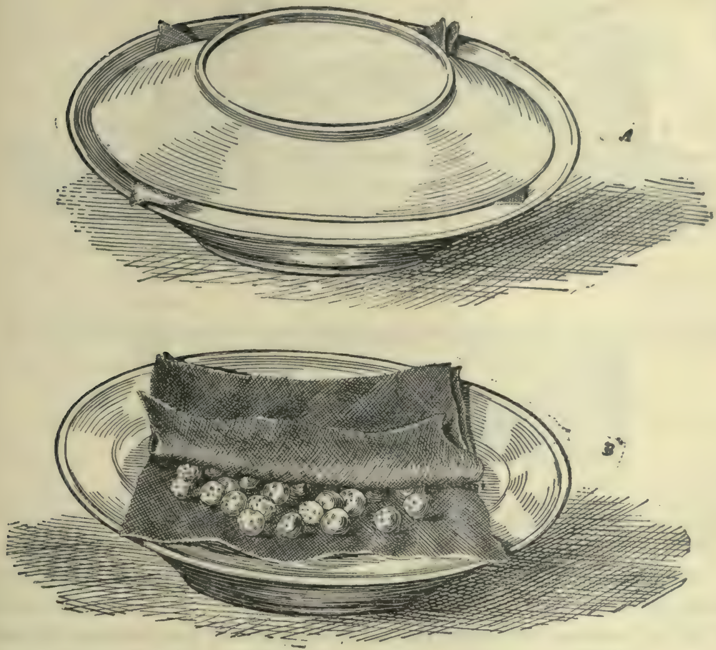

Fig. 1. Simple germinating apparatus. a, closed; b, open. (After Pieters). From U. S. Dept. Agr. Year-book, 1895.

First method.—(See figure 1.) Take two plates and place in one of them a folded cloth, preferably wool and undyed, though other cloth may do. Wet the cloth, wringing out the surplus water. Place the seeds to be tested between the moist folds and cover with the second plate so as to hold moisture and exclude light. Moisten the cloths as necessary.

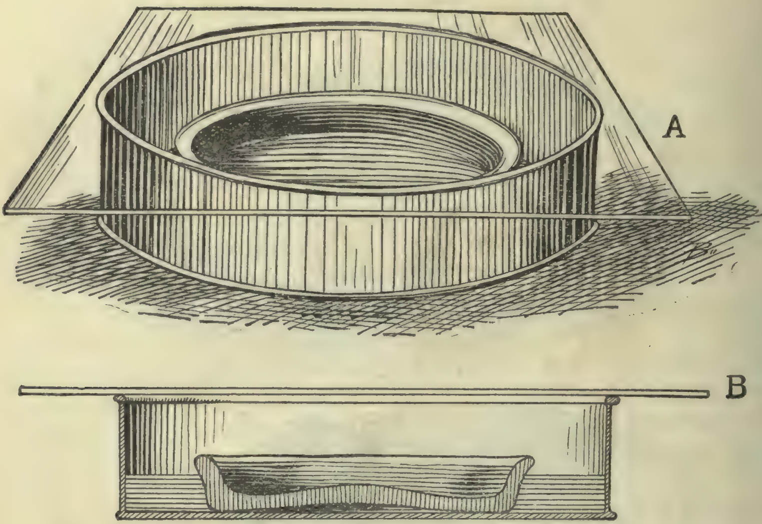

Fig. 2. Home-made germinating apparatus. a, complete; b, section. After Pieters, from U. S. Dept. Agr., Year-book (1895).

Second method.—(See figure 2.) Place a common flower pot saucer of porous clay in a larger dish, which should be agate ware, or, if tin, coated with mineral paint to prevent rusting. Add water to the outer dish to about one-half the height of the porous saucer. The water will then soak through sufficiently to keep the inner surface of the saucer favorably moist. The seeds are laid in this saucer, preferably covered in folds of cloth or blotting paper, although this is not necessary. The whole should be covered to exclude light and retain moisture.

Third method.—Soak well a handful of cotton batting in water, spread it in the bottom of a non-rusting dish, place the seeds to be tested on the cotton, add water to cover the bottom of the dish, and cover the dish to exclude light and hold moisture.

It is well to immerse the cloths and dishes in boiling water shortly before beginning the tests to kill moulds which may be clinging to them and which may otherwise cause trouble.

In making the test a definite number of seeds should be counted out, say 100, 200, or more. Under favorable conditions grass and clover seeds should begin to sprout in about three or four days. The sprouted seed should be removed each day, the number being recorded. The test should be continued ten days or somewhat longer if the conditions are unfavorable.

LEGISLATION

The joint resolution passed by the General Assembly of 1902 which led to this examination, was inspired by the hope on the part of certain members thereof that legislation might be invoked to better the conditions of the seed trade. In order to facilitate the consideration of this matter at the recent (1904) session, a compilation of the seed legislation of other states was made. For most of the data used we are indebted to Mr. Edgar Brown. A full review of these laws would be out of place here, but a summary seems pertinent. The more important state laws are those of Florida,[1] North Carolina,[2] Kentucky,[3] and Maine.[4]

A comparison of these laws shows that their chief provisions fall into three classes:

1st. Requirements that packages of seeds be stamped with the year or place of growth (North Carolina, Florida).

2nd. Forbidding specified adulterations (Kentucky).

3rd. Requirements of printed guarantee of percent of purity (Maine).

In all cases so far as information has been secured the requirements of the first class are not operative. A similar law in Vermont was a dead letter and was repealed in 1904. The conditions found to exist in Vermont hardly seem to justify legislation of the second class. The requirements of the third class promise most of value in securing improvement under the conditions existing in Vermont. We therefore append the Maine law in full:

LAWS OF MAINE, 1897, CHAPTER 313.—AN ACT TO REGULATE THE SALE OF AGRICULTURAL SEEDS

SECTION 1. Every lot of seed of agricultural plants, whether in bulk or in package, containing one pound or more, and including the seeds of cereals, except sweet corn, grasses, forage plants, vegetables and garden plants, but not including those of trees, shrubs and ornamental plants, which is sold, offered or exposed for sale for seed by any person or persons in Maine, shall be accompanied by a written or printed guarantee of its percentage of purity, freedom from foreign matter; provided, that mixtures may be sold as such when the percentages of the various constituents are stated.

SEC. 2. Dealers may base their guarantees upon tests conducted by themselves, their agents, or by the director of the Maine Agricultural Experiment Station; provided that such tests shall be made under such conditions as the said director may prescribe.

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[1] Laws of Florida, chapter 4754 (No. 13).

[2] Laws of North Carolina (Session 1890) chapter 331.

[3] Laws of Kentucky (Session 1904) chapter 82.

[4] Laws of Maine (Session 1897) chapter 313.

SEC. 3. The results of all tests of seeds made by the said director shall be published by him in the bulletins or reports of the Experiment Station, together with the names of the persons from whom the samples of seeds were obtained. The said director shall also publish equitable standards of purity, together with such other information concerning agricultural seeds as may be of public benefit.

SEC. 4. Any person or persons who shall sell, offer or expose for sale or for distribution in this State agricultural seeds without complying with the requirements of Sections 1 and 2 of this act shall, on conviction in a court of competent jurisdiction, be fined not to exceed one hundred dollars for the first offense and not to exceed two hundred dollars for each subsequent offense.

SEC. 5. Any person or persons who shall, with intention to deceive, wrongly mark or label any package or bag containing garden or vegetable seeds or any other agricultural seeds, not including those of trees, shrubs and ornamental plants, shall be guilty of a misdemeanor and upon conviction in a court of competent jurisdiction shall be fined not to exceed one hundred dollars for the first offense and not to exceed two hundred dollars for each subsequent offense.

SEC. 6. The provisions of this act shall not apply to any person or persons growing or selling cereals or any other seed for food.

SEC. 7. Whenever the director of the Maine Agricultural Experiment Station becomes cognizant of the violation of any of the provisions of the act, he shall report such violation to the secretary of the Board of Agriculture, and said secretary shall prosecute the party or parties thus reported.

SEC. 8. All acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 9. This act shall take effect September 1st, 1897.

Approved March 26, 1897.

The Maine station reports that this law has proved fairly satisfactory, and that under its operation there has been an appreciable improvement in the quality of the seed sold in that State. At the same time the experience in other states indicates that there is no hope of securing a radical change in the seed supply as a result of any legislative enactment. The most important advance must come from such education of the buyers as will lead them to demand the best seed the market affords and to see that they get it. The education of the dealers themselves is also a matter of considerable importance. Indeed, the chief value of the Maine law is attributed to its educational effect upon buyers and dealers. Should the principle of this law be accepted for Vermont, it is suggested that it be restricted in its application to the agricultural grasses and clovers. As embodying this idea in its simplest form, the following section was drafted at the request of the Senate Committee on Agriculture of the last General Assembly, accompanied by a penal clause relating to unguaranteed or overguaranteed sales:

"Every lot or parcel of grass or clover seed, including millets and alfalfa, whether in bulk or in package, containing five pounds or

more, which is sold, offered or exposed for sale by any person or persons in Vermont, shall have affixed thereunto in a conspicuous place on the outside thereof, a legible and plainly written or printed statement showing its percentage of purity; provided, however, that mixtures may be sold as such when the percentage of the various constituents is stated."

REPORT OF THE HORTICULTURIST

Wm. Stuart

The work of the horticultural department for the past year has been confined largely to the problems stated in the last annual report. The greenhouse investigations with tomatoes and lettuce have been so far concluded as to permit of some statement of the work done. The subjects upon which report may be made are as follows:

Some Problems in Winter Forcing of Tomatoes.

Some Studies in Indoor Lettuce Culture.

Bridge-grafting a Girdled Apple Tree.

The Preparation of Bordeaux Mixture.

Etherization as an Aid in Rhubarb Forcing.

The study of the disease resistance of potatoes to "late blight" (*Phytophthora infestans*) has been continued and greatly enlarged. Plant-breeding work has been given much more attention than last year, several hundred seedling potatoes having been grown and a considerable number of successful crosses made on some of the wild species of solanums. It is proposed to enlarge the work greatly during the coming season.

Observations on the blossoming, leaving out, formation of terminal bud and fruiting period of plums and cherries have been continued for the Division of Pomology of the National Department of Agriculture.

During the current year a new experimental apple orchard of over two hundred trees and embracing over forty varieties has been started. It is hoped that this orchard may serve as a basis of many practical investigations in fruit culture.

Many queries were made in the spring regarding the peculiar behavior of apple trees. The trouble was described by practically all the correspondents as follows: The trees blossomed and partially or wholly leaved out, when growth was arrested and the leaves began to wither and dry up. Later on most of these trees pushed out many new shoots at the base of the scaffold limbs or on the trunk just below their juncture with it. Two orchards in which this injury was re-

dollar. Some Vermont buyers paid twice as much for plant food as did others.

How, when and what to buy are discussed, systems of fertilization, methods of application, and the kinds of plant food best fitted for sundry purposes are outlined and eighty formulas for all sorts and conditions of crops, with suggestions as to their use, are offered.

The analyses of the fertilizers sold in Vermont in 1905 appear on pages 222-232 of the bulletin.

A comparison of analyses of brands for five years shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods.

CONCERNING DISEASE RESISTANCE OF POTATOES

L. R. Jones

A considerable part of the time of the writer has been given to the preparation of a report upon potato diseases, with special reference to disease-resistance of varieties. This is the outcome of several months spent in a visit to the chief potato growing sections of Europe, supplemented by inquiries in America. It was undertaken in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, and has been just (December, 1905) issued from the press.[1]

Since this investigation is of general rather than local interest and will be available to such of the readers of this report as care to send to the Department for it, it does not seem wise to republish anything here except the following summary which is quoted from the close of the bulletin cited:

From the nature of this bulletin it is not practicable to summarize all parts consistently. The following points are those of chief practical interest:

The aim of the bulletin is to present in concise form what is known about disease-resistance in potatoes. Much of this information is from European sources.

Certain minor diseases of obscure nature, but apparently nonparasitic are first considered,—internal brown spot, filosité and leaf spot. Among other remedial measures for each is that of selection of resistant varieties.

Scab-diseases of tubers are in most cases, and perhaps in all of parasitic origin, fungus or bacterial. Apparently the variety of these is greater in Europe than in America, but the severity is less there. It is undecided to what extent the American type of scab occurs in Europe, so a close comparison of conditions and remedies is not practicable. In Germany certain varieties are known to be more scab-resistant than are others, among them being Richter's Imperator, Professor Wohltmann and Irene. The same is true in America, White Beauty leading the list so far as known. Other American varieties showing a considerable degree of resistance are Carmen No. 3, American Giant, Sir Walter Raleigh and Irish Cobbler. Scab Proof and Aurora are also highly commended for scab-resistance.

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[1]Jones, L. R., Disease Resistance of Potatoes, U. S. Dept. Agr., Bu. Pl. Ind., Bul. 87 (1905).

Various stem-diseases of the potato are known. The commonest type in Europe is termed Black-leg (Schwarzbeinigkeit) a bacterial disease. It is not known to occur in America, but it resembles certain maladies which do occur here and which are as yet imperfectly understood. Varietal resistance to black-leg is not fully established, but apparently Dabersche and certain similar thick-skinned starch-rich late varieties are more resistant than thin-skinned starch-poor early varieties of the Rose type. Factor and Up-to-date showed a considerable degree of resistance to black-leg in England. La Czarine and other varieties are reported to show resistance to a bacterial stem disease in France.

The late blight and rot due to the fungus *Phytophthora infestans* occurs more commonly in Europe than in America. Attention has been given for many years to relative varietal susceptibility to this disease, especially in Great Britain and Germany. Varieties of superior disease-resistance are known in both countries and a number of the most promising from these and other European sources have been imported for trial.

The following statements are tentatively formulated as to the nature of resistance toward blight and rot and the characters of the varieties exhibiting it:

1. Disease-resistence in potatoes is relative, not absolute, no variety known being wholly proof against late blight and rot.

2. It seems related to general vegetative vigor and is therefore in a measure dependent upon cultural and developmental conditions and tends to decrease with the age of the variety.

3. It can be restored by originating new varieties from seed, especially if of hybrid origin. Not all seedlings show superior disease-resistance.

4. The use of other species of tuber-bearing Solanums for hybridizing offers some promise, but no practical results have yet been secured.

5. Possibly the disease-resistance in established varieties can be improved by selection, but this has not been proved.

6. Early varieties may escape the disease by maturing before it becomes epidemic, but when similarly exposed they are as a class less resistant than late varieties.

7. The source of seed-tubers is a matter of importance, northern-grown seed giving plants of superior disease resistance in Europe. Seed from a crop that was not too highly fertilized is probably preferable. Possibly tubers are better for seed purposes if dug before they reach full maturity.

8. High fertilization, especially with nitrogenous manures, lowers the power of the plants to resist both blight and rot.

9. Varieties relatively rich in starch are more resistant to rot and those richer in nitrogen are more susceptible to it.

10. So far as skin characters are an index the thicker rough-skinned red varieties seem more resistant as a class than the thin-skin white varieties.

11. So far as stem and foliage characters are concerned the evidence favors a stem that is hard, rough and rather woody at the base and small, somewhat rough and dark-colored leaves.

The varieties rated highest as to disease-resistance in England are: Evergood, Discovery, Royal Kidney, Northern Star, Sir John Llewelyn, King Edward VII, Eldorado, Factor.

In Germany and Holland the following represent the best types: Mohort, Irene, Geheimrat Thiel, Professor Wohltmann, Boncza, Eigenheimer, Paul Krüger.

In Belgium and France no improvement as to disease-resistance has been made over the best English and German types.

In America trials as to disease-resistance have been conducted at some of the Experiment stations, notably in Vermont, where experiments in breeding and selection for increased resistance are under way.

Their results have been correlated with information recently secured by a circular of inquiry addressed to a large number of potato specialists in the northeastern states and Canada. From these it appears that a wide variation is shown in disease-resistance among the varieties now in cultivation, but that no one variety is preeminent. Among those which have been rather widely tested, the following deserve mention as of the resistant class: Dakota Red, Rust Proof, Irish Cobbler, Sir Walter Raleigh, Doe's Pride, White Beauty. Certain European varieties of the disease-resisting type seem to hold that character as grown in this country, e. g. Professor Maerker and Sutton's Discovery. There is much of promise in certain new varieties under trial at the Vermont Station. Several sorts of reputed disease-resistance have recently been placed on the market by American seedsmen, e. g. Harris' Snowball, Dibble's Ionia Seedling, Burpee's Vermont Gold Coin, Johnson's Norcross, Star of the East and Babbitt. Those having opportunity should carefully observe the relative disease-resistance of these and also of other new varieties.

The evidence at hand seems to justify the hope that the combined efforts of potato specialists working from both the practical and scientific standpoints, may result soon in the development of varieties of potatoes, combining general excellence with a high degree of disease-

resistance. All who can do so are urged to aid toward the accomplishment of this end.

THE OCCURRENCE OF PLANT DISEASES IN VERMONT IN 1904

L. R. JONES and W. J. MORSE

The close relationship between plant diseases and weather conditions was noted in the last report. In order to give a basis for continued comparison the following record for the year is inserted, based on data furnished by Messrs. W. B. Gates, observer at Burlington, and W. A. Shaw, observer at Northfield, for the Weather Bureau of the United States Department of Agriculture:

	Mean temperature	Mean temperature for * years	Total rainfall	Average total rainfall for * years	Number clear days	Number cloudy days	Number partly cloudy days
Burlington—							
May,	56.5	58.5	2.58	3.10	12	7	12
June,	63.7	67.6	4.70	3.42	9	8	13
July,	70.0	71.4	7.67	4.08	10	6	15
August,	66.0	68.6	3.98	4.14	12	4	15
September,	60.7	61.7	4.32	3.62	9	12	9
Northfield—							
May,	52	53	1.74	2.10	4	11	16
June,	59	62	3.89	3.16	4	13	13
July,	66	66	6.17	3.72	2	9	20
August,	61	63	4.02	2.40	12	10	9
September,	55	56	4.35	2.91	7	12	11

*Burlington, 22 years; Northfield, 19 years.

The results of these conditions were a vigorous development of agricultural crops in general and, with a few exceptions, a relative freedom from disease.

ORCHARD CROPS

The apple and pear diseases of chief importance in this region are scab (*Venturia*) and blight (*Bacillus amylovorus*). Neither of these maladies has done serious harm since the remarkable spring drought of 1903, which evidently almost exterminated these parasites from Vermont orchards. Except for this fact there could hardly have failed to be considerable scab the past season. As it was there was only a

moderate development of this fungus and small loss, despite the fact that less than the usual amount of orchard spraying was done. There was more scab than in 1904, however, and in the writer's judgment there is a sufficient reestablishment of the fungus in most Vermont orchards to augur serious damage from it another year, providing weather conditions favor. The renewal of spraying operations where they have been held in abeyance the past two seasons is therefore to be urged. The same general statements will apply as to the occurrence of the blight. Less than usual has been observed since the drought but enough was seen this summer to start the epidemic next year if climatic conditions favor.

The injuries resulting from the winter killing of 1903-04 were still in evidence this summer, many of the trees which recovered showing but weakly growth. In one such case, examined in August, 1905, it was found that most of the wood of the preceding year was brown and dead, although the cambium had survived and given a weakly growth during the last summer.

The cherry and plum crops were heavier than common in 1905. The brown rot (*Monilia*) made its appearance unusually early, attacking the fruit spurs of the sweet cherry in some cases before the flowers were fully faded. It continued to develop persistently on the sweet cherries and, later, on the more susceptible varieties of plums, destroying not only the young fruits but killing the fruiting twigs back to the main branches. Probably the average loss amounted to from 10 to 25 percent of the crop. Extra precautions should be taken this winter to clean out such orchards.

GARDEN CROPS

No maladies of peculiar interest were observed on garden crops other than the potato. Some cases of bacterial soft rots of vegetables came to our notice. In one of these, turnips were growing alongside rutabagas. The former rotted badly, while the latter showed none of the trouble, indicating clearly a relatively greater liability of turnips to the disease. The Station horticulturist observed a similar bacterial rot of the tap-root of parsley. This was growing in soil where turnips rotted badly last year, and is strong evidence that these diseases are perpetuated from crop to crop in garden soils. The increasing number of reports of club-root of cabbage and allied crops indicate that the germs of this disease are being more widely scattered year by year. Where one values his soil for the production of these cruciferous crops he should be cautious about setting purchased cabbage plants unless

he knows them to be from soil free of the disease. It is believed that much new infection has occurred in this way in Vermont during recent years.

POTATO DISEASES

The climatic conditions of the summer of 1905 were in general favorable for the potato crop until September.

Tip-burn.—Tip-burn did only a moderate amount of damage, less than it ordinarily does.

Early blight.—There was less early blight (*Alternaria solani*) than usual, except on light soils. On these it developed destructively throughout August and early September and materially shortened the life of the plants, as will be shown in detail later in this report.

Late blight and rot.—The amount of rot which occurred in 1904 made the recurrence of the late blight in 1905 a certainty, provided climatic conditions favored. Until the latter part of August such conditions were not generally present. This blight was first observed on potato leaves August 13. Thereafter it spread but slowly for some time. Examinations of numerous fields made August 23 showed that the fungus occurred in practically all of them, but it was not as yet conspicuously destructive anywhere, early blight being much more in evidence at that date. During the last week of August, however, it spread persistently, but did not become generally conspicuous until the first week of September. This week was warm with frequent gentle rains and the foliage on all except favorably situated or resistant varieties rapidly blackened and was soon practically ruined. The weather continued sufficiently rainy for two weeks thereafter to afford ideal conditions for the rot and the resultant loss was exceptionally great, many fields on low or heavy soil not being worth the digging. That this is in considerable degree unnecessary is shown later in this report.

The opportunity which the senior writer enjoyed of observing the potato maladies of Europe in 1904 gave him a special incentive for keeping a close watch for the occurrence of any of these in the fields here under observation in 1905. Particular attention was given to the following:

Black leg, the *Schwarzbeinigkeit* of the Germans, is a well-marked potato disease common in Europe, characterized by a soft rot of the base of the stem. Nothing of this was seen here. Neither was there any evidence in our fields of the similar rosette disease, which Selby has described as associated with the common *Rhizoctonia* of the potato. The latter fungus is common as a surface saprophyte

upon potato tubers, forming black flecks and creeping over the underground surface of the bases of the stems. Evidence of the fact that it is essentially a surface saprophyte was observed when the stalk was cut from vigorous young potato plants about the middle of July. One of the stumps protruded some three inches above the surface of the soil. This was seen on July 24 to be covered with a white fungus growth for two inches above the soil and examination showed it to be a basidiomycetous fungus, believed to be *Corticium vagum* var. *solani*, Burt, the fruiting stage of the Rhizoctonia. The tip of the stump showed a bacterial soft rot, but the stem tissues underneath the fungus were hard and green, the fungus growth apparently being incapable of causing serious lesion even when developed thus abundantly and upon weakened tissues.

Leaf spot diseases.—Two leaf spot diseases of minor importance were observed for the first time. The first of these began to show upon two separate hills in one of the experimental fields early in July. One of these was of the Boss, the other of the Snow variety. The appearance of small black spots on the leaves suggested early blight at first glance, but upon closer observation it was seen that as a rule the blackening began on the underside of the veinlets and spread more rapidly along the veins than laterally. No fungus which could account for this spotting was detected on these plants then or at any time during the next four weeks, during which their development was kept under observation. One hill was dug up July 18, when the seed tuber, root system and stem bases seemed sound. The other was kept under observation till its death about September first. The spots gradually enlarged, bearing a close resemblance to early blight but continuing sterile; nor was the true early blight seen upon this or any adjacent plants. The older leaves gradually died and the spotting appeared on the younger leaves from the time of their unfolding during August. It was in our judgment a non-parasitic malady involving the plant as a whole, the local spotting of the leaves being merely the symptom. This is undoubtedly the same trouble that was seen by the senior writer in Germany and also in England, and called by Dr. Sorauer "Flecken necrosis." A discussion of this malady has already been given in more detail in the departmental bulletin hitherto cited (foot note page —). Suffice it to add here that it was not seen upon any other hills of these varieties or on any of the large number of other varieties under trial at this Station, including many from Europe as well as from America. A similar malady was, however, common on the Mexican *Solanum polyadenium* in the horticulturist's potato collection.

Another disease unrecorded in America so far as can be learned, and certainly never seen by the writers, appeared in a potato field under observation this year. It was first seen on an early planted piece of Early Rose potatoes. Obscurely defined pale yellowish spots, one-eighth to one-fourth of an inch in diameter were seen upon the lower leaves of many of the plants when in early blossom about the first of July. The lower surface of these spots was covered with a delicate gray growth, which the microscope showed to be the richly fruiting threads of a fungus, evidently a *Cercospora.* These spots increased in number and somewhat in size during the next two weeks, so that by July 15 most of the leaves on the lower half of the plants showed the spots, and some spots were appearing on the upper leaves. These began on the leaves while they were of a normal green color, indicating that the fungus is parasitic, but of the class of weakling parasites, i. e. it attacks only the foliage which is declining in vigor. In the gross appearance of the spots and in its occurrence and destructiveness it was much like *Cladosporium fulvum*, which was developing at this same season on the leaves of neighboring tomato plants. In the later stages of its development the fungus growth was often apparent on the upper side of the leaf as well as upon the lower. In some cases the invaded spots blackened and died while the rest of the leaves remained green. More usually, however, the entire leaf slowly yellowed and shrivelled. This spotting spread during July over an unknown variety of potato immediately adjacent to the Early Rose, and in August and September a slight development occurred upon several other varieties of later potatoes which were a few rods removed from these. It caused a considerable damage from hastening the death of the vines of the earlier potatoes. There was no way of measuring this loss, as it was uniformly distributed over the piece, but it was estimated as equivalent to a mild attack of early blight and reduced the yield by perhaps one-fourth. It did no harm of practical consequence on the later varieties.

The fungus is now being studied in the laboratory and a later publication will probably deal with its specific and cultural characters.

POTATO DISEASES AND THEIR REMEDIES

L. R. JONES and W. J. MORSE

I. RESULTS FROM SPRAYING EXPERIMENTS

SPRAYING THE VINES FOR LATE BLIGHT AND ROT

The potato field chosen for the spraying experiments against late blight and rot in 1905 was planted the middle of May with Delawares. The soil was a gravelly loam in good fertility, well drained and excellently adapted for potatoes.

Twenty-four rows were staked off for the experimental work, the balance being sprayed in connection with the regular farm operations. These twenty-four rows were divided into four plots of six rows each. Plots 1 and 3 were sprayed alike with bordeaux mixture, plots 2 and 4 being left as controls and treated only with paris green in lime to ward off insect injuries.

The bordeaux mixture used consisted of 6 pounds of copper sulphate, 4 pounds of lime and 40 gallons of water, with the addition of one-half pound of paris green. Two applications of this mixture were made on August 2 and 21, respectively. The first traces of the late blight fungus were seen on the leaves of the control rows August 13. It spread but slowly until about September first. Thereafter, being favored by moist warm weather it worked rapidly over these rows, soon destroying the tops. The sprayed plants held their foliage well through September. The plots were dug and sorted October 13. The outside rows of each plot were rejected to insure greater accuracy. The results as shown by the remaining rows are as follows, expressed in bushels per acre:

Plot	Treatment	Yield sound	Rotten
I.	Bordeaux mixture,	342	8
II.	No fungicide,	191	46
III.	Bordeaux mixture,	422	4
IV.	No fungicide,	232	66
	Average where sprayed,	382	6
	Average where not sprayed,	221	56
	Gain from spraying,	161	

It is evident from these figures that as heretofore there was a large gain from the use of bordeaux mixture. These results are in agreement with those extending now over fifteen successive years. We have always found spraying a profitable procedure with early potatoes because of its effect in warding off insect attacks and early blight, aside from the general stimulation it affords to the plants. Evidence on these points secured this season is presented later in this

report, page 275. But the greatest gains have always been found with the later crop, i. e. vigorous main crop varieties planted in May and maturing in the autumn. The following table fairly presents the results obtained during fifteen years and furnishes such conclusive evidence as ought to impress potato growers of this section with the idea that *proper spraying pays*.

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre where sprayed	Yield per acre where not sprayed	Gain per acre
White Star	May —, 1891	Aug. 26, Sept. 8	313 bu.	248 bu	65 bu.
" "	May 20, 1892	July 30, Aug. 13, 25	291 "	99 "	192 "
" "	May 20, 1893	Aug. 1, 16, 29	338 "	114 "	224 "
" "	Apr. 26, 1894	June 16, July 17, Aug. 30	323 "	251 "	72 "
" "	May 20, 1895	July 25, Aug. 13, 31	389 "	219 "	170 "
Polaris	May 15, 1896	Aug. 7, 21	325 "	257 "	68 "
"	June 1, 1897	July 27, Aug. 17, 28	151 "	80 "	71 "
White Star	May 10, 1898	July 21, Aug. 10	238 "	112 "	126 "
Average, 3 varieties	May 18, 1899	July 26, Aug. 17, Sept. 8	229 "	161 "	68 "
Delaware	May 23, 1900	Aug. 4, 23	285 "	225 "	60 "
"	May 25, 1901	July 20, Aug. 21	170 "	54 "	116 "
"	May 15, 1902	Aug. 1, 20	298 "	164 "	134"
Green Mtn.	May 1, 1903	Aug. 10	361 "	237 "	124 "
Delaware	May 25, 1904	Aug. 1, Sept. 1	327 "	193 "	134 "
"	May 15, 1905	Aug. 2, 21	382 "	221 "	161 "
Average of 15 years			295 "	176 "	119 "

SPRAYING THE SOIL TO PREVENT THE ROT

Practically all of the potato rot which occurs in Vermont is due to the late blight fungus, and to the decay of the tubers which follows the development of the fungus on the foliage. Attention was called in a former report[1] to the controversy which often arises as to whether tuber infection is due to the passage of the fungus down the blighting stems or whether it results from the washing or migration of the spores through the soil. The publication referred to reports upon trials designed to throw light upon this matter by spraying the surface of the ground with bordeaux mixture. The trials were repeated in 1905.

Details of experiment.—Delaware potatoes were planted June 10 upon a heavy, moist clay loam, which had been well manured with the expectation of planting it to corn. Eight rows of these potatoes were selected for the trial. On August 2, before any signs of the late blight appeared on the leaves, the surface of the soil under four of these rows was thoroughly sprayed with bordeaux mixture, care being taken to get none of the mixture on the foliage. This procedure

[1] Vt. Sta. Rpt., 15, p. 218 (1902).

was repeated on August 18. Up to this time no late blight had been seen on these plants. It appeared soon after, however, and developed persistently and destructively throughout September, the foliage being practically all destroyed by it. Meanwhile, on August 28, a third and final spraying was made of the surface of the soil. Thus the soil under one-half of the plants was sprayed three times, with control rows untreated. No fungicide was applied to the foliage of any of the plants and the late blight was rampant on all alike. Since September was a rainy month and this clay soil especially favorable to rot, the conditions were ideal for a severe development of the disease in the tubers. The following figures show that such a development occurred. The tubers were dug on October 13, at which time there was but little life left in the tops. Since the four rows where the soil was sprayed adjoined the four unsprayed control rows, it seemed safer, in order to avoid possible cross contamination, to make use of the results afforded by the middle two rows only of either plot. The yields were as follows:

Soil sprayed. Sound tubers, 60.2 pounds; rotten tubers, 12.5 pounds.
No treatment. Sound tubers, 13.5 pounds; rotten tubers, 57.9 pounds.

Where no treatment was given, 81 percent rotted in the ground; where the soil was sprayed, only 17 percent rotted.

Discussion of results.—The data obtained in the similar trial of 1902, already referred to, are pertinent here. The disease was not as severe then, but the outcome was as follows:

Soil sprayed. Sound tubers, 151 pounds; rotten tubers, 2.5 pounds.
No treatment. Sound tubers, 113 pounds; rotten tubers, 26 pounds.

When reduced to percents the 1902 results show 19 percent of rot where the soil was not sprayed as compared with 2 percent where it was sprayed.

The results of the two trials are in general agreement, therefore, in showing not only that the disease passes from leaf to tuber, but that the main channel at least is through the soil rather than through the stem. This is in accord with the explanation of the habits of the fungus generally accepted by botanists, viz., that the tubers rot because of infection by spores developed on the foliage and thence finding their way through the soil, largely by being washed there by rains. The fact that there was considerable rot this year in spite of the spraying appears to contradict the claim that *all* of the tuber infection is to be thus explained. Observations which are to be discussed later (page 285) lead to the conclusion that there is some spread of the fungus from tuber to tuber in the soil. The conditions were favorable for this in the above experiment of 1905, but not so in 1902, and

the difference in results is probably largely due to this fact. While soil spraying is not to be recommended in practice, it may be noted that in the later sprayings when the disease is bad and soil heavy it may pay to make extra heavy applications of the mixture, that enough may reach the surface of the soil to check the development of the fungus spores falling thereon.

SPRAYING AS A REMEDY FOR EARLY BLIGHT

The climatic conditions during the growing season of 1905 were in general sufficiently moist and cool to be generally favorable to the development of the potato, especially during the latter part of the summer. This resulted in less than the usual amount of early blight (*Alternaria solani*), which is a disease characteristic of hot, dry weather. The only exception observed was on the experimental field situated on the sand plain farm belonging to the University. The 1904 crop on this piece was practically a failure owing to early blight. Foreseeing a probable repetition of the trouble on the same field this year, a spraying experiment was planned to determine how far bordeaux mixture will check the disease under these conditions. While evidence has been secured in previous years that it will do so in some measure, difficulty has been experienced in formulating exact conclusions because of the usual complication of late blight or other troubles with the early blight.

Details of experiment.—The soil is a light sandy loam recently cleared from pitch pine, and planted with potatoes in 1904 as well as the present year. The crop was planted June 9 in drills 40 inches apart, 15 inches between sets. There were thirty-six rows altogether, each 60 feet long, consisting of six rows of each of the following varieties: Rural New Yorker No. 2, Delaware, Green Mountain, Polaris, Early Rose and Early Ohio.

It will be noted that this series includes a representative set of standard varieties, ranging in season from the earliest like Early Ohio to medium late like the first three. The conditions proved ideal for the test of the question proposed. Owing to the lateness of planting and the favorable summer, all varieties alike continued their growth until well into the autumn. Moreover, there was during the last six weeks of their life a typical and severe development of the early blight fungus upon the foliage, with practically no complication with other maladies such as late blight and tip-burn. The standard bordeaux-paris green mixture[1] was used on the sprayed rows and paris green

[1] 6 pounds copper sulphate, 4 pounds lime, 40 gallons water, ½ pound paris green. The control rows were dusted with one part paris green in 15 parts air slaked lime.

and lime applied to the control rows. Upon one-third of the rows, two of each variety, the bordeaux-paris green mixture was applied five times, July 15 and 24, August 2, 18 and 28. Upon another third, only three applications were made, the second and fourth being omitted. The other two rows left as controls received three applications of paris green and lime dusted upon the plants freely. This sufficed to keep them free from the larvae or young slugs of the potato beetle. Grasshoppers and mature potato beetles wrought some injury in September upon the unsprayed rows, while there was practically no damage done to the sprayed rows. This must be held in a minor way responsible for the difference in yield which will be explained later, but it does not in any way affect the validity of the conclusions as to the efficacy of bordeaux mixture as a remedy against the early blight fungus.

Development of disease.—Leaf spots showing the presence of the early blight fungus were abundant upon the unsprayed plots before the middle of August, and by the last of the month, taking the average of all varieties, about one-half of the foliage was killed. The extent of the injury varied, however, in direct proportion to the natural earliness of the maturity of the variety, as will be seen by a glance at the following records of conditions on August 28:

DAMAGE FROM EARLY BLIGHT ON UNSPRAYED PLANTS

Variety	Foliage killed	Variety	Foliage killed
Rural New Yorker No. 2	15 percent	Polaris	50 percent
Delaware	25 "	Early Rose	75 "
Green Mountain	50 "	Early Ohio	90 "

There was an abundant sprinkling of early blight spots on the remaining unsprayed foliage of all varieties at this date and all the tops on the unsprayed rows died during the next fortnight.

The crop on the sprayed plots showed a striking contrast to these. There was a slight amount of early blight present on the plants sprayed three times, though not enough to have caused practical injury. Careful search revealed scarcely a spotted leaf on those sprayed five times. During the following fortnight there was a slight increase in the amount of this spotting on the plants sprayed three times, though not enough to be of practical consequence; while those sprayed five times remained almost without a spot until the end of the season. This came on September 13, when all were cut down by an early frost.

The yields were as follows in pounds per row;

	Sprayed 5 times	Sprayed 3 times	Not sprayed
Rural N. Y. No. 2,[1]	60	74	55
Delaware,	59	52	23
Green Mountain,	54	49	22
Polaris,	40	42	27
Early Rose,	64	42	12
Early Ohio,	54	57	30
Totals,	331	316	169

[1]There was a large stump in these rows, which accounts for the relatively small gain shown where sprayed five times.

These figures are in complete accord with the verdict that had been reached from the appearance of the tops, viz.: that there was very decided gain from the spraying and that five applications is slightly better than three, but not enough so to be of much practical consequence.

Discussion of results.—Judging from the appearance of the plants, we attribute a considerable, perhaps nearly one-half, of the actual gain in yield to the beneficial effects of the bordeaux mixture in other ways than in checking the early blight fungus., i. e. in deterring insects from attacking the plants and in promoting their general vigor. Fully one-half was due to checking the early blight fungus. The foliage was practically free from the attacks of the late blight (*Phytophthora*) and there was no rot in any of these rows. It was therefore as complete a demonstration as could be desired of the efficacy of bordeaux mixture as a remedy for early blight, providing it is applied *thoroughly* and *in season.* We emphasize these points because, according to our observations, few potato growers realize sufficiently their importance.

II. RELATION OF DATE OF DIGGING TO DEVELOPMENT OF ROT

Investigation into this question in previous years[1] has led to interesting conclusions of much practical significance. The conditions of the summer of 1905 were somewhat different from those when the previous trials were made, so it was thought desirable again to make trial diggings at different dates.

Details of experiment.—The soil was a heavy undrained clay loam, ill adapted to potato culture at best, and especially so in a wet season like that of 1905. The variety was State of Maine, planted about the middle of May. No fungicides were applied. The late blight fungus appeared on the foliage about the 20th of August and spread slowly

[1]Vt. Sta. Rpt. 17, p. 391 (1904) and earlier literature there cited.

but persistently until the middle of September, when substantially all the tops were dead. Owing to the frequent September rains this soil was wet practically throughout the month. This fact must be borne in mind in considering the results. Part of the tubers were dug on each of two dates, September 9 and October 7. These were in each case wet, with considerable soil clinging to them when dug. They were allowed to lie in the field a few hours to dry off, then stored in shallow boxes, well ventilated, in a dry cellar at a temperature of 50-55° F. There was some loss of weight attributable to the dirt which rattled off these tubers at the later weighings, but this was essentially the same in all rows, and since the data give comparative rather than absolute values, this may be disregarded. The results as to total yields and subsequent rot are as follows:

DETAILS AS TO YIELDS AND DECAY WHEN DUG AT DIFFERENT DATES

Row No.	Date of Digging	Condition when dug				Condition Sept. 15				Condition Nov. 11			
		Sound		Rotten		Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I	Sept. 9	580	88 lbs.	0	0 lbs.	560	78 lbs.	20	3.6 lbs.	440	56 lbs.	120	17.6 lbs.
II	Oct. 7	288	44.3 lbs.	250	38.5 lbs.	....	....	....	....	244	34.8 lbs.	44	6.7 lbs.
III	Sept. 9	558	88 lbs.	0	0 lbs.	498	74.4 lbs.	60	8.6 lbs.	333	43.2 lbs.	165	2.4 lbs.
IV	Oct. 7	214	31.5 lbs.	270	39.8 lbs.	....	....	....	....	194	25.8 lbs.	20	3.9 lbs.

Adding together the results from rows I and III and from II and IV respectively, the following figures are obtained:

Dates of Digging	Total amount when dug		Condition when dug				Final condition				Percent of crop saved	
			Sound		Rotten		Sound		Rotten			
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	By no.	By weight
Sept. 9	1138	176 lbs.	1138	176 lbs.	0	0 lbs.	773	99 lbs.	365	54 lbs.	68%	56 %
Oct. 7	1022	154 lbs.	502	76 lbs.	520	78 lbs.	438	61 lbs.	584	88 lbs.	43%	40 %

Discussion of results.—The results are capable of but one interpretation. There was greater loss from the later digging than from the earlier. This is an outcome radically different from those of the previous trials extending through the three years 1902-04 and involving the averages from six fields and five varieties in 1902, one field and one variety in 1903, and one field and six varieties in 1904. In the light of these former results that of 1905 may be held to be the exception which may prove the general rule. Fortunately, observations,

which will be discussed in detail later, were also made at digging time which explained the result. Suffice it to say here that it was found that owing to the excessive rain and the heavy soil the rot fungus (*Phytophthora*) was forming spores on the surface of many of the tubers during the latter part of September. This has never before been observed by us, and is probably an exceptional thing. Yet it is doubtless the fact that a considerable part of the rot which destroyed the later dug tubers in the present field was the result of inoculation from such spores in the soil between the dates of the earlier and later diggings. Reviewing the details of our former results in the light of this conclusion, we are led to believe that a similar condition of affairs has only once before occurred, viz., in the south plot of Holt's field, 1902.[1] The figures there show a loss from late digging about like the present and the soil conditions were similar, viz., a heavy wet clay loam. The rule[2] which was formulated as the result of previous experiments was favorable to late digging where the rot is feared. We would now modify it by making an exception of heavy wet soil in a wet season. Of course every potato grower avoids such soil as unsuited to the crop anyhow, providing he has other soils available, so this exception really affects but a minor portion of the crop. While this is our conclusion to date, it is planned to continue these trials upon various types of soils and under varying conditions as to disease until no doubt can be left in the matter.

III. RELATION OF STORAGE CONDITIONS TO DEVELOPMENT OF ROT IN POTATOES

Favorable opportunity was secured for making a number of experiments to determine the relation of storage conditions to the development of rot in potato tubers. For this purpose tubers were taken from the same field as in the preceding experiment. As explained, these were State of Maine potatoes and the soil was a heavy, moist, clay loam. The soil is poorly suited to potato growing in any season, and was especially so where there was much rain in late summer as in 1905. No fungicide was applied to the plants and the late blight developed considerably on the tops. The rains kept the soil so continually wet during September that much of it clung to the tubers at digging time. Every condition, therefore, favored a considerable development of rot in the storage cellar. With this expectation in mind, four questions were formulated, some having a more direct practical interest than others:

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[1] Vt. Sta. Rpt. 15, pp. 219-224 (1902).

[2] Vt. Sta. Rpt. 17, p. 395 (1905).

1. Does liming prevent rot?
2. Will disinfection with formalin lessen rot?
3. Will sun-drying the tubers lessen rot?
4. What is the relation of temperature of storage to rot?

DOES LIMING PREVENT ROT?

Results obtained during the last two years[1] have given negative replies to this question. Since the conditions of the field just described promised an excessive loss from rot, it was decided to repeat the trial once more. In order to test the lime more thoroughly it was decided to try it on both moist and dry tubers. Therefore two rows were selected. The digging was begun on the morning of a bright, clear day, and the tubers of the first row were dug early and allowed to dry thoroughly before taken to the cellar. Those of the second row were taken in while still moist, indeed almost wet, the ground being low and damp. No rotten potatoes were found in the first row at digging time, and only three in the second; but the occurrence of late blight on the tops, together with the soil conditions, made us confident that there would be a considerable rot in the tubers. When the tubers were placed in storage air-slaked lime was scattered over one-half of each lot, at the rate of a pound of lime to three bushels of potatoes. This sufficed to give the surface of each potato a liberal coating, and certainly is as much as anyone who has either to use or to attempt to sell the tubers would ever apply. All were stored in shallow boxes, well ventilated, in a dry cellar at a temperature of 50-55° F. They were sorted twice, first September 15, one week after storing, and again on November 11. The results follow:

Row No.	Condition when stored	Treatment when stored	Amount when stored		Sorted Sept. 15				Sorted Nov. 11			
					Sound		Rotten		Sound		Rotten	
			No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I a	Dry	Lime	159	22 lbs.	141	18.2 lbs.	18	2.1 lbs.	102	10.3 lbs.	39	6.3 lbs.
I b	Dry	None	145	22 lbs.	140	19.5 lbs.	5	0.9 lbs.	112	14.0 lbs.	28	4.3 lbs.
II a	Moist	Lime	109	22 lbs	92	17.0 lbs.	17	2.9 lbs.	55	8.3 lbs.	37	7.4 lbs.
II b	Moist	None	134	22 lbs	118	17.8 lbs.	16	2.5 lbs.	80	10.8 lbs.	38	5.4 lbs.

Bringing these figures to the percentage basis, it appears that the losses were as follows:

[1]Vt. Sta. Rpts. 16, p. 163 (1903), 17, p. 395 (1904).

Dry, limed.	35% of number,	52% of weight
Dry, no treatment,	23 "	36 "
Moist, limed,	50 "	61 "
Moist, no treatment,	40 "	54 "
Average, limed,	42.5 "	66.5 "
Average, no treatment,	31.5 "	45 "

It is evident, therefore, that instead of being an advantage in the preservation of the tubers, the lime appeared actually to favor the rot.

Discussion of results.—In the first place it would be well to compare these results with those of the preceding trials, taking the loss in weight as the basis of comparison.

In 1903, loss where limed,	29%;	no treatment, 27%
In 1904, loss where limed,	9%;	no treatment, 11%
In 1905, loss where limed,	66%;	no treatment, 45%

In two years out of three, therefore, the loss from rot in the limed potatoes was actually greater than in the unlimed ones. It is hard to escape the conclusion, therefore, that instead of checking the rot, liming probably actually favors it. Certainly when one takes into consideration the further fact that the lime coating makes the tubers disagreeable to handle and hard to prepare for cooking, it becomes evident that liming potatoes is to be condemned as worse than useless. As noted last year, the evidence so far as obtained by others favors this same conclusion.[1]

WILL DISINFECTION OF TUBERS LESSEN ROT?

So far as is known to the writers this question has never been determined, unless the use of lime as described in the last experiment be considered a disinfecting process. Although it might not usually seem practicable to disinfect potatoes, even if there was some lessening of rot by some such process, yet one can conceive of conditions where such a procedure would be applicable, especially for growers of seed potatoes. Moreover, it is of considerable interest as contributing to the understanding of the time and mode of infection by the fungus.

Details of experiment.—The potatoes were left on the ground several hours after digging to sun-dry, and as they were gathered up they were carefully divided into two lots, one-half from each hill going into each lot. Lot I received no treatment; lot II was soaked for an hour in a solution of 8 ounces of Merck's formalin in 15 gallons of water, i. e. 0.4 percent solution, the same strength as used in disinfection against scab. These tubers were then spread upon the cellar

[1]Vt. Sta. Rpt. 17, p. 397 (1904).

bottom for twenty-four hours to dry. Both lots alike were stored in shallow wooden boxes, well ventilated, in a dry cellar held at a temperature of 50-55° F. The outcome was as follows:

Lot No.	Treatment before storing	Amounts stored		Sorted Sept. 15				Sorted Nov. 11			
				Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I	None	290	44 lbs.	280	39 lbs.	10	1.8 lbs.	220	28 lbs.	60	8.5 lbs.
II	Formalin	293	44 lbs.	272	38.1 lbs.	21	2.9 lbs.	231	29.5 lbs.	41	5.7 lbs.

From these figures it is evident that the formalin disinfection was without material effect in checking the rot. This result is the more noteworthy in view of the fact that these tubers had much of the clay soil clinging to them and that the untreated tubers were in a moist condition when stored.

Relation of moisture to rot.—Of course the presumption is that tubers will keep better if dried before storing and kept dry thereafter. Since the soil was very wet at time of digging in one field where rot was feared, it was considered worth while to put this matter to the test. Accordingly, two rows were dug on a very bright sunny autumn day, favorable to quick and thorough drying. One-half of each hill was picked up promptly after digging while still moist and constituted the lots called *a*. The other half of each hill was left in the sun several hours and turned once meanwhile, thus securing pretty thorough sunning and drying of the surface; these constituted the lots called *b*. All were stored alike in a dry cellar in shallow, well ventilated boxes at 50-55° F. Very little rot was found in these at digging time, September 9, but as was expected, much developed in storage. The tubers were sorted twice with the following results:

Row No.	Condition when stored	Amounts stored		Sorted Sept. 15				Sorted Nov. 11			
				Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I a	Moist	279	44 lbs.	230	30.6 lbs.	49	8.5 lbs.	163	19.0 lbs.	67	7.9 lbs.
I b	Dry	306	44 lbs.	271	36.2 lbs.	35	4.1 lbs.	200	24.5 lbs.	70	9.4 lbs.
II a	Moist	335	55 lbs.	295	44.5 lbs.	40	6.3 lbs.	200	25.3 lbs.	105	13.8 lbs.
II b	Dry	349	55 lbs.	311	46.5 lbs.	38	5.4 lbs.	208	27.0 lbs.	103	15.0 lbs.

It is evident, therefore, that the results were more favorable where the tubers were stored dry, whether one considers number or weight

of sound tubers on November 11. Averaging the two lots and reducing to a percentage basis the gain is as follows: Based on numbers of tubers, 62 percent of the crop was saved where stored dry as contrasted with 59 percent where stored moist. Based on weight of tubers, 52 percent was saved where stored dry as contrasted with 45 percent where stored moist. It is further noteworthy that the gain occurred, as one might naturally expect, during the first few days following storage; indeed, in the last period there was slightly more loss among those which were dried before storing. One is led to ask why this is so. Three possible explanations occur to us. First, it may be due to infection during storage, as shown later in this report; second, it may be that the moister conditions stimulate or favor a more vigorous or destructive development of the fungus already in the tubers; third, it may be that the moister condition of the tubers keeps them in a condition permitting or favoring destructive invasion by the fungus. Whatever the explanation, the practical conclusion is the same, viz.: that potatoes should be allowed as much exposure to sun and air as practicable before storage, providing loss from rot is anticipated.

RELATION OF TEMPERATURE OF STORAGE TO DEVELOPMENT OF ROT

Everyone realizes the probable importance of this factor. Potatoes are, however, so little handled in cold storage in the regions where rot prevails that no exact records have been secured on this point so far as we know. The following experiments were planned with this end in view:

Some six bushels of tubers were dug September 22 from the field already described and divided into three like portions. Each was placed in a barrel. The first was stored near the greenhouse boiler at a temperature approximating 70° F.; the second in a cellar at 50-55° F.; the third in a cold storage house at 40° F. The tubers of lots I and II were sorted twice, but to simplify the presentation only the final conditions are presented as existing on November 18, when the last sorting was done:

Lot No.	Storage temperature	Amounts stored Sept. 22		Conditions Nov. 18				Percent of crop saved	
				Sound		Rotten			
		No.	Weight	No.	Weight	No.	Weight	By no.	By weight
I	70	850	116 lbs.	275	86 lbs.	575	65 lbs.	32%	31 %
II	53	691	116 lbs.	352	54 lbs.	339	51 lbs.	51%	47 %
III	40	756	116 lbs.	650	96 lbs.	106	17 lbs.	86%	83 %

Discussion of results.—This outcome is one of the most interesting of the entire series and of much practical significance. Potatoes have sold in the Burlington market this year for 80 to 90 cents a bushel. There would have been an immense saving and a wide margin of profit if more potatoes had been placed in cold storage. While it may not prove practicable for the smaller growers to do this, it certainly behooves everyone to appreciate the importance of placing the crop in the coldest storage room available and as promptly as possible after digging, when much rot is anticipated. It is proposed later to transfer to a warm room portions of these tubers which have been kept from rotting by cold storage. It is of practical as well as theoretical interest to learn whether in such case further rot will develop in midwinter.

IV. STUDIES AS TO THE TIME AND METHOD OF TUBER INFECTION BY THE ROT FUNGUS

This is a question of much practical importance and about which there is incomplete knowledge. It has generally been held by plant pathologists that it results from spores borne on the leaves and washed thence through the soil to the tubers. The results of our soil spraying experiments already described are in general agreement with this idea. Granting this, however, some practical questions remain unanswered.

Does the fungus spread from tuber to tuber in the soil?

Can such infection occur with fully mature tubers or only with the immature ones?

May tuber infection result from the contact of spore bearing tops with tubers at digging time?

First, as to the possibilities of spread from tuber to tuber in the soil. It has heretofore been stated that there was much rainfall in September and close watch was kept of the progress of the fungus upon the tubers growing in moist heavy clay loam. On the area under consideration the blight destroyed practically all of the foliage before the middle of September. Meanwhile the rot had begun to develop upon the tubers, very little being found September 9. It rapidly spread during the last half of the month. Upon digging at different times and places during this period the fungus (*Phytophthora*) was frequently found growing in tufts from the surface of such decaying tubers; and such tufts were always richly covered with spores. Moreover, soil conditions were favorable for their development and for further infection of tubers, as was shown by the fact that some of these spores were found in process of germination, i. e. zoospore

formation. Moreover the fungus threads or mycelium were found ramifying through the interstices of the soil for one-fourth to one-half of an inch from the surface of such decaying tubers and there sporulating abundantly. Doubtless this growth was made possible in the soil by the impregnation of the earth by the juices or infusions from the decaying potatoes which were close at hand.

These observations convinced us that the fungus was under these circumstances capable of spreading from tuber to tuber in the soil. Evidence that this actually occurred was presented earlier in this report, pages 274-275, in connection with the account of the trial as to digging at different dates. That experiment was made in this same field and showed a rapid increase in amount of rot where the tubers were left in the ground during the last half of September, although, as already stated, the foliage was practically all destroyed earlier. In the light of our experience, however, such rapid and destructive spread of the fungus from tuber to tuber in the soil is believed to occur but exceptionally, probably only in wet heavy lands. Further observation on this point is needed, since it is of much practical significance.

These observations led to the giving of more careful attention than heretofore to the possibilities of infection of the matured tubers either by contact with spore bearing foliage at digging time or by spread of the fungus from tuber to tuber during storage. The following results show that infection may occur in either way if conditions are sufficiently favorable.

In order to test the possibility of infection of tubers by spores from the foliage at digging time, the following experiment was carried out: On September 9 some State of Maine potatoes were dug, whose tops had blighted badly and were two-thirds dead. The tubers appeared fairly mature. Less than four percent of rot showed at digging time. Subsequent developments of the rot showed that more infection had occurred in the field than was suspected at the time, otherwise tubers from another source would have been chosen. The soil was wet and much clung to these tubers, making them quite dirty and moist. They were taken to the storage cellar before fully dry and there divided into three lots of 44 pounds each. One lot (III) was at once placed in the storage cellar without treatment to serve as a control. Each of the other two was poured into a laundry tub with bottom drainage and treated as follows: One lot (I) was covered with a layer of potato branches, the leaves of which showed a considerable development of the blight fungus. To insure the fuller distribution of the fungus spores over the tubers water was then sprinkled over this foliage freely until it trickled from the bottom of the tub. The

sprinkling was repeated at the end of twenty-four hours, and when this foliage covering was removed from the tubers at the end of thirty-six hours it was still fairly fresh and bearing a rich crop of spores. There would seem to be the best possible chance for tuber infection under the circumstances.

Meanwhile the other lot (II) had lain in a similar tub without artificial infection, but covered with coarse sacking and water sprinkled over it the same as over I. It was designed to serve with lot III as a control on lot I.

Upon removing lots I and II from the tubs at the end of the thirty-six hour period they were wet and muddy. Lot II and one-half of lot I (called Ia) was placed in shallow layers on the cellar floor to dry, and when so dried at the end of twenty-four hours, was stored alongside of III. The other half of the lot (called Ib) was handled in the same way except that the mud was first washed from the tubers by a stream of water from the garden hose pipe. To recapitulate, then, the treatment of the three lots was as follows:

I. All tubers exposed for thirty-six hours to infection from blighting tops immediately after digging; one-half (Ia) left unwashed, the other half (Ib) washed.

II. Not artificially infected but kept moist for thirty-six hours after digging as was I.

III. Stored without treatment immediately after digging.

All were kept in like storage in ventilated shallow boxes in a dry cellar at a temperature of 50-55° F. They were sorted twice, with the following results:

Lot No.	Treatment before storing	Original weight	Sorted Sept. 15		Sorted Nov. 11	
			Sound	Rotten	Sound	Rotten
I a	Infected, unwashed	22 lbs.	17.7 lbs.	4.1 lbs.	1.6 lbs.	13.0 lbs.
I b	Infected, washed	22 lbs.	14.8 lbs.	6.0 lbs.	0 lbs.	12.4 lbs.
II	Control, kept moist	44 lbs.	34.2 lbs.	6.0 lbs.	10.1 lbs.	19.0 lbs.
III	Control, untreated	44 lbs.	35.6 lbs.	5.0 lbs.	20.2 lbs.	11.0 lbs.

The relative loss was, therefore, about 92 percent where infected and not washed, 100 percent where infected and washed, 77 percent where not infected but kept moist for thirty-six hours, and 54 percent where stored at once without any treatment. There can be no doubt from these figures as to the possibility of tuber infection at digging time, provided conditions are sufficiently favorable, i. e., an abundance of spores and moist conditions. Probably the higher percentage of infection where the tubers were washed was simply due to bringing

the spores which were already on the tubers into closer contact with their surface, and especially of lodging them in the eyes along with adequate moisture for their germination. It is possible that a part of the excess of loss in lot II over lot III was due to infection following digging by spores clinging to the tubers. Most of it is, however, attributed to the stimulation to hastened growth of the fungus already present in these tubers.

Concerning the possibility of spread in the storage cellar, positive evidence has been obtained along two lines:

First.—Spores may be produced in storage. Reference has been made to the abundant sporulation of the fungus on decaying tubers in the soil. Equally rich crops of spores were found in stored potatoes during October. Moreover, these were on tubers in shallow boxes in a dry cellar at temperature of 50 to 55° F. Doubtless they would be produced more abundantly under moister and warmer conditions.

Second.—Well ripened sound tubers were taken during this same month (October) and successfully inoculated[1] with the fungus spores.

Such inoculations have been secured by applications of the spores to cut surfaces of the tubers, but almost as certainly by placing drops of spore-containing water in the eyes of mature tubers kept in a moist chamber. The results leave us in doubt as to the outcome from similar applications upon lenticels. Probably, however, infection does not occur through the lenticels or the unbroken epidermis of the mature tubers.

There can be no doubt, therefore, as to the possibility of infection of tubers in storage. Probably many tubers are so infected during the first fortnight after digging where there is much moisture and a high storage temperature, say above 60°F. It is not thought that there is enough danger to be of practical moment, however, providing the tubers are dry when placed in storage and kept continuously dry and cool during the first month thereafter.

V. GASEOUS DISINFECTION FOR POTATO SCAB

This is a direct continuation of the trials which have been made during several preceding years[1] aiming to secure a satisfactory method for the disinfection of seed potatoes by gaseous treatment in lieu of soaking. These preceding trials have encouraged belief in the efficacy of formaldehyde gas for this purpose. The aim in the present trials was, first, again to test the fundamental question of the relative value of gaseous treatment as compared with soaking the seed for dis-

[1]These inoculation experiments were performed by Mr. N. J. Giddings, a student in the botanical laboratory.

[1]Vt. Sta. Rpt. 17, p. 397 (1904) and previous reports there cited.

infection against scab; and, second, to make trial of the merits of different ways of generating the gas.

The experiment was carried out, as heretofore, on recently cleared pine land, virgin soil, which is a light sand and supposed to be free from the scab germs.

The Delaware variety has proved in our trials to be especially liable to scab, so it was selected for use. One-half the seed used was very scabby, every tuber having the surface sufficiently pitted by the disease to render it unmarketable. The other half was perfectly smooth seed, but sorted from a crop showing considerable disease, and so presumed to have the spores or germs of the disease on the surface. To make such infected condition the more certain, dust and scrapings from scabby tubers were sprinkled over the surface of this smooth seed before disinfection. The aim was to secure in this way a condition of seed infection at least as bad as would exist in any case where smooth tubers were sorted from a lot containing much scab.

These smooth and scabby seed tubers were then each divided into five lots, there being a little less than a peck of each lot. These lots were handled in pairs in the subsequent disinfecting and planting, i. e. a scabby and a smooth lot going together to constitute a pair, treated alike and planted as two parallel rows in one plot. The treatments before planting were as follows:

I. Soaked two hours in a solution of 8 ounces of Merck's formalin in 15 gallons of water. This is the standard method of disinfection and used as a basis for comparison.

II. The dry seed inclosed for 24 hours in a tight box of 8.2 cubic feet capacity, into which was conducted the gas (formaldehyde and water vapor) generated by the evaporation of 25 c. c. of Merck's formalin diluted with water. At the beginning 100 c. c. of water was added and this was constantly replenished, so that at the end of one hour one-half the volume of the liquid still remained. This was then boiled down to about 10 c. c. This method has been found to vaporize all the formalin.[1]

III. Dry seed enclosed for 24 hours in a tight box as in II, except that the gas was generated by the permanganate method.[2] This consisted in placing in the disinfecting box a shallow dish with flaring sides, containing 9.375 grams of potassium permanganate, and pouring on this 25 c. c. of Merck's formalin (i. e. in the proportion of three

[1]For further details as to this method see Vt. Sta. Rpt. 17, p. 398 (1904).

[2]This method of generating the gas was first advocated and its usefulness for general disinfecting purposes shown by Evans and Russell, Maine State Bd. Health Rpt. 13 (1904). The details of the trials there given show that 81 percent of the total gas in solution is liberated by this method and so suddenly as to increase its effectiveness.

parts permanganate to eight parts formalin). The box was sealed immediately after the addition of the formalin and so left for 24 hours.

IV. The formaldehyde gas generated as in III, but instead of leaving the seed in a dry atmosphere, water vapor (steam) was conducted into the box for one hour, exactly as in lot II. The aim here was to secure conditions identical with II as to moisture conditions, but differing as to the method of volatilization of the formaldehyde gas.

V. Left untreated as a control.

A thermometer in the disinfection box showed the temperature to range from 60° to 70° F. during the experiment, except during the discharge of vapor into the box in experiments II and IV, when it ranged between 70° and 80° F.

The planting was done May 5, in plots following the order just given, each plot consisting of two rows 75 feet long, one planted with scabby, the other with smooth seed of like treatment, one-half peck of seed per row. Each plot was separated from the next by 25 feet of unplanted ground to lessen danger of cross infection. All germinated well and alike, there being no evidence of ill effect of the treatment upon the growth. The plants were dusted with paris green on July 15 and five applications of bordeaux-paris green mixture were made on subsequent dates at intervals of about a fortnight during July and August, as in the spraying experiment already described for prevention of early blight.

They were dug October 13 and subsequent sorting showed the following conditions as to yield and scabbiness. The variations in yield should be accorded no consideration, since all the plants were equally healthy. They resulted from the local soil variations, largely due to the interruption of the rows by the remains of pine roots and stumps.

Plot No.	Treatment of seed	Condition of seed	Total yield		Smooth tubers		Scabby tubers		Percent scabby	
			No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
				lbs.		lbs.		lbs.		lbs.
I.	Soaked in formalin sol.,	Smooth,	436	46.4	417	44.4	19	2.0	4	4
		Scabby,	324	24.0	281	20.4	43	3.6	13	15
II.	Formalin vaporized,	Smooth,	537	48.3	528	47.9	9	0.4	2	1
		Scabby,	578	49.2	561	47.8	17	1.4	3	3
III.	Permanganate method,	Smooth,	498	31.3	469	29.0	29	2.3	6	7
		Scabby,	450	38.0	441	36.5	9	1.5	2	4
IV.	Permanganate meth. & steam,	Smooth,	374	27.8	363	26.8	11	1.0	3	4
		Scabby,	354	31.7	343	30.4	11	1.3	3	4
V.	Control; no treatment,	Smooth,	310	33.2	225	22.7	85	10.5	27	32
		Scabby,	389	34.2	119	12.7	270	21.5	79	63

Discussion of results.—In all our potato scab experiments minor irregularities have occurred, due probably to variations in soil, drainage or humus content or, possibly, to cross infection in the field. The larger percent of scab from the smooth seed of plot III above is an example of this. With this exception the results are so uniform that there can be no doubt as to the conclusions. Scabby seed gives a far scabbier crop than smooth seed. All the methods of disinfection show marked gains, but none of them gives a crop wholly free from the scab. All of the vapor methods gave results which average ever better than did the soaking in formalin solution. Since these results are in accord with those of previous trials,[1] they are convincing as to the efficacy of formalin gas as a disinfectant against scab.

The other question is as to the best method of generating and applying the gas. The evidence seems on the face of it to favor slightly the direct vaporization of formalin by heat (plot II above). The difference between that and plot IV, where the permanganate method of gas generation was employed, is so little as to lead us to consider it within the limits of experimental error. In any case it is only a slight matter. In view of the relative convenience of the permanganate method it is to be recommended for practical use. The final question is as to whether this may be used alone as in plot III or whether in the presence of steam as in plot IV. The results this year apparently favor the use of steam. Again the difference is a small one and evidently within the limits of error, since in the case of the smooth seed, plot III, the evidence favors steam, while with the scabby seed it is against it. In the trials of former years, as detailed in the reports already referred to, the use of steam apparently reduced rather than increased the efficacy of the gaseous disinfectant. In view of this fact, therefore, the writers are led to recommend for practical use the generation of gas by the permanganate method and without the addition of steam.

The experiment was carried out on too small a scale to justify final conclusions as to the penetrating power of this gas into a bin of stored potatoes. It also leaves open the question of the minimum amount of formalin needed per cubic foot.

Careful observations have been made on both of these points by bacteriologists in connection with the use of this gas for disinfecting houses suspected of harboring germs of human diseases. They have found this formaldehyde method effective and the gas to have power of penetrating and disinfecting blankets, etc. In general the recommendations are to use 10 ounces of formalin per 1,000 cubic feet with

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[1] Vt. Sta. Rpt. 17, p. 401 (1904) and references there given.

closure of the room for 24 hours. Dr. B. H. Stone of the Vermont State Laboratory tells us that he prefers twice this amount for insuring the highest efficacy. In the experiments of Evans and Russell, already referred to, one quart per 1,000 cubic feet was used and found sufficient for perfect disinfection in three hours. In our trials 25 c. c. for 8.2 cubic feet were used, or the equivalent of about three quarts per 1,000 cubic feet. Since this amount did no harm there can be no objection to the use of so much except on the ground of added cost. From the evidence at hand we should advise for practical purposes that this be reduced by one-half, i. e. three pints per 1,000 cubic feet. This would still be from three to five times the amount required for bacterial disinfection. We believe that if this amount is used and the storage cellar be closed very tightly so as to hold the gas for forty-eight hours after its generation, it would penetrate ordinary potato bins, i. e. to a depth of several feet. It would be preferable, however, if practicable, to have the potatoes lying in shallow layers of say not over one foot depth.

To generate the gas on a large scale an earthenware basin (wash-bowl) or jar is the best dish to use. It should have a capacity of about a gallon for each pint of formalin; e. g. a three gallon dish if three pints of formalin are to be used. The formula requires that three parts of potassium permanganate be mixed with eight parts of formalin. Thus three pints (pounds) of formalin require 18 ounces of permanganate. This should be placed in the bottom of the jar, then the formalin poured over it, the operator at once retiring from the room and closing it as tightly as possible. The cost of the chemicals as quoted by retail druggists would approximate $1.50 per 1,000 cubic feet. As stated in former reports, the ordinary potato grower will do better to disinfect his seed by soaking in the formalin solution. This method of gaseous disinfection is recommended only for those seed potato specialists who may wish to disinfect hundreds or thousands of bushels of tubers.

FURTHER STUDIES IN LETTUCE CULTURE

WM. STUART

Lettuce culture was discussed under three heads in the last annual report:[1]

(1) The comparative value of different forms of chemical fertilizers;

(2) The relative value of chemical fertilizers and rotted manure;

(3) The relative influence of surface and sub-watering.

The subjects discussed in the present article are:

(1) Flat grown versus bench grown plants;

(2) Combination indoor and outdoor lettuce culture.

I. FLAT GROWN VERSUS BENCH GROWN PLANTS

The usual practice of market gardeners in this vicinity is to grow lettuce rather close together in the greenhouse bench, say from four to six inches apart, and when about two-thirds grown to transplant to flats or boxes averaging 12x15 to 14x20 inches in surface area, and containing from one to two dozen plants. This rather unusual practice is the result of a preference on the part of the dealers thus to handle open head or curly lettuce. The grower receives forty cents per dozen for plants thus raised.

The object of the present trial was to determine whether it was feasible to grow the plants in flats, from the time of transplanting to the bench till ready for market, and, if so, whether relatively as good returns could be secured. The flats used were especially constructed for the purpose, having interior dimensions of 12x16x3½ inches, and were designed to hold one dozen plants. The bench grown plants were set at a distance of 8x8 inches or four times the surface area of those in flats. This space was allowed because previous trials had shown that Grand Rapids lettuce would easily occupy, and indeed required, all this area for its full development. In order to furnish an abundance of plant food to the flat grown plants, the bottom of the flat was filled to a depth of 1½ inches with well rotted manure. The soil in the bench was also liberally supplied with rotted manure. Two sections in the lettuce room, each containing a superficial area of about 68 square feet, were equally divided, one-half of each being occupied by the flat grown plants, the other by those grown in the bed.

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[1]Vt. Sta. Rpt. 17, pp. 431-439 (1904).

THE OCCURRENCE OF PLANT DISEASES IN VERMONT IN 1906

L. R. Jones and N. J. Giddings

POTATO DISEASES

The climatic conditions of spring and early summer were in general favorable to the potato crop. Unusually heavy mid-summer rains followed by hot and dry weather favored certain pests and diseases later in the season and checked the development of others.

Insects. The Colorado beetle and flea-beetle were common and destructive where the plants were not well protected by sprays.

Sun scald and tip burn. The rains of early July followed by several hot dry days caused sun scald of numerous leaves in the experimental fields as well as in many other parts of the State. At this season the plants quickly recover and the harm is usually trifling. It is worthy of note only that it may be distinguished from the more serious blights which come later. The continued hot dry weather of August parched most soils and the trouble known as tip burn was common as a consequence. The important thing to note in connection therewith is that it is not a fungus trouble and spraying does not, therefore, directly control it. Indirectly it does so by keeping off insects and blights and so contributing to the general health of the plants. The measures more directly called for are attention to soil tilth, cultivation, and, if practicable, irrigation.

Early blight. This disease, caused by the fungus *Alternaria Solani,* was responsible for unusually large losses in certain fields. It appeared early in July and, helped by the hot dry weather of the latter half of that month, it spread rapidly on potatoes on the lighter soils. By August first it was hard to find a leaf unspotted by this blight in some such fields near Burlington. The fact that spraying with bordeaux mixture is

a fairly effective preventive of this disease was again evident. The relative immunity from early blight of potatoes on heavy soils was clearly shown by the comparative conditions on two of the experimental plats which were planted and treated practically alike. Although the early blight occurred on the clay loam the damage caused by it was relatively unimportant as compared with that on the sandy loam.

Late blight and rot. The occurrence of rot caused by the late blight fungus (*Phytophthora infestans*) was so general in Vermont potatoes in 1905 as to lead to the expectation of a general recurrence of the disease in 1906 providing weather permitted. The moist warm weather of early July favored the fungus upon the early crop and specimens of this leaf blight were received from Barton on July 11. This is noteworthy as the earliest date when the appearance of the fungus has been recorded in Vermont, July 13, 1902, being the record date heretofore. It was not seen at Burlington until the first of August. It then had a strong start on a single field of early potatoes and had evidently been present there for at least ten days. Thereafter it spread quite rapidly for a week or more, causing considerable loss by blight and some rot. The hot dry weather beginning in late July and continuing through early August so checked its spread that practically none of the late blight occurred on medium and late potatoes in this vicinity and there was no loss in the main crop from rot. In the more moist and cool mountainous regions, however, the blight continued to spread as usual during August and September and the loss from both foliage blight and subsequent rot was estimated at from 25 to 75 percent of the crop. While the experimental plats were free from this disease there was enough infection of seed tubers in the state at large to insure the destructive recurrence of the malady in 1907 should weather conditions favor.

Potato leaf blotch. Reference was made in our last report[1] to a leaf spot disease not heretofore described in America and

[1] Vt. Sta. Rpt. 18, p. 271 (1905).

due to a fungus of the genus *Cercospora*. This disease appeared again in 1906. Its characters are such that the writers are calling it the *potato leaf blotch* disease to distinguish it from the other leaf spots and blights. It is not known how general its occurrence may be, but it is believed to be at least frequent, especially in long cultivated soils, such as old gardens, and that it has heretofore been overlooked merely because confused with the familiar early and late blights. Further details regarding this malady are presented on pages 236 to 257.

Potato scab. The dry warm weather of the later summer seemed to have a restraining influence upon the development of scab. At least less evidence of this disease than usual came to the writers' attention. No experimental plats were devoted to its special study, however, during the past season.

Black leg. Reference was made in the last report[1] to the black leg type of potato stem diseases, characterized by the blackening of the base of the stem and the slow death of the plant, although nothing of this sort was observed that year. In 1906, however, a considerable outbreak of this malady occurred in one of the experimental fields. Obscure reports of stem troubles of this kind and that next described have reached the Station from time to time in previous years and this fact coupled with what is known as to their importance in Europe have led the writers to give more attention to this disease than its economic importance, as it occurred in the home field, would alone seem to justify. This disease is, therefore, made the subject of a special article on pages 258 to 266 of this report.

The potato wilt disease. As already stated obscure reports have reached us from time to time of potato stem diseases. Some of these were apparently of the type described as black leg, others occurring on the potato and also on the tomato were of a different type which may best be described as wilt diseases. An important contribution to our knowledge of these diseases was the publica-

[1] Vt. Sta. Rpt. 18, p. 269 (1905).

tion by Smith and Swingle[1] of studies showing that the fungus *Fusarium oxysporium,* often associated with dry rot of stored potatoes, may invade the roots and stems of the plants as a parasite and cause a wilt disease of the stems followed by the invasion and dry rot of the tubers.

The experimental plats of the horticultural department include a large number of varieties of potatoes brought from widely different sources. The soil is a sandy loam. On August 9th it was noted that the stalks of one hill of potatoes were all freshly wilted. On the 10th another entire hill was affected and by the 13th fifteen hills of this and other adjacent varieties showed one or more stalks drooping. Five other hills wilted during the next few days. Six American varieties were included in these twenty hills. All of this occurred in an area of about two square rods at one side of the two acre field, and nowhere else on the entire field did a single plant show this wilt disease. All of the affected plants died and dried up within a few days. Several of them were taken up and examined. There was no blackening of the stem below ground as in the preceding disease. The stem would often show dead shrunken areas upon the surface, which might, however, be above ground. The pith in these, especially the basal part, was dried out and so shrunken that the greater part of the interior of the stem was hollow. The fungus *Rhizoctonia* was commonly found on the surface of such stems below ground, but since it was equally common on healthy plants little importance should, in our judgment, be attached to this fact. More significant was the occurrence of *Fusarium* upon the surface and within the pith cavities of the wilted stems. Pure cultures were obtained which correspond in all characters with *Fusarium oxysporium* as described by Smith and Swingle. The wilted plants were carefully labelled and the tubers kept separate. At digging time some were cut open but nothing of an unusual character was observed. Nor have any

[1]Smith, E. F. and Swingle, D. B. The Dry Rot of Potatoes due to the Fungus *Fusarium oxysporium.* U. S. Dept. Agr., Bu. Pl. Ind., Bul. 55 (1904). (1904).

signs of the *Fusarium* rot appeared in them up to mid-winter. While the observations thus far made would not justify an independent conclusion, the general symptoms of the disease and the occurrence of the fungus lead the writers to regard this as the same type of wilt disease that was described by Smith and Swingle and attributed to the parasitism of the *Fusarium.* Studies will be continued upon the tubers later in the winter and such further observations made as conditions will permit. Meanwhile specimens are solicited from correspondents who may note anything of this trouble.

ORCHARD DISEASES

Scab of pear caused by the fungus *Venturia pirina,* formerly known as *Fusicladium,* and the closely related *apple scab, Venturia inaequalis* were common and destructive. While the injury to apples was not great, the fungus appeared to some extent on all susceptible varieties and its presence is, therefore, a constant menace to orchardists. The pear scab developed so in this vicinity as entirely to ruin the fruit of the more susceptible varieties like Flemish Beauty. It has repeatedly been shown experimentally and in orchard practice that intelligent spraying will control these diseases; therefore, it is only necessary to emphasize that after a respite of some years they are present again in full virulence and to urge that orchardists guard against their havoc by spraying.

Fire blight. The bacterial disease due to the invasion of the young twigs and branches by *Bacillus amylovorus,* was seen occasionally but was not destructive enough to cause much damage. It has been thus in abeyance for several years, and where it has entirely disappeared, orchardists, especially those having young pear trees, should vigilantly guard against its reinvasion of their orchard. Where there are lingering cases of it, severe pruning out and burning of all infested branches should be practiced before the spring of 1907.

Apple canker continues its destructive invasion especially of the older trees in unsprayed orchards. The direct cause in

all cases examined is the fungus *Sphaeropsis malorum*. This fungus also attacks the fruits as they ripen causing the so-called black rot. This rotting of the fruit does not occur commonly enough to be of much practical importance in Vermont. Other causes of apple canker than this black rot fungus occur in the apple growing states farther south and west and examinations are now being made to see whether any of these are operating here also. The botanical department will gladly receive and examine doubtful specimens. While the fungus named is probably the immediate cause of most if not all the Vermont canker, its invasion is far more serious on trees weakened by the oyster-shell-bark louse or other insects, or by age coupled with lack of proper culture and pruning. Although the thorough use of fungicides is the most important and direct remedy it should be accompanied by attention to these other matters.

Apple rust, another fungus disease, was reported again last year. The cause of this is traceable to curious fungus growths on red juniper (commonly called red cedar). Almost every red juniper tree in Vermont will be found upon examination to bear on its smaller branches the warty brown swellings, termed cedar apples, varying in size from a pea to a walnut. These are due to the fungus *Gymnosporangium macropus*. In late spring spores are developed on these which are carried thence to the young foliage of any apple or wild thorn apple tree in the nighborhood and cause them to rust. Experiments made here some years ago showed that while it is not easy to prevent this by spraying, the destruction of the red juniper in the vicinity of the orchard at once stops the trouble.[1] Since this juniper is a plant of small economic importance in this State there will ordinarily be no hesitancy in so handling the problem when the facts are understood.

Black Knot of plum. This well known disease caused by the fungus *Plowrightia morbosa* is common throughout the State on both wild and cultivated plums and cherries and numerous

[1] Vt. Sta. Rpt. 6, p. 83 (1892).

inquiries relative to it were made during the season. Prompt and thorough pruning coupled with spraying suffice to hold it in check. Infected wild trees should not, of course, be allowed to grow in the vicinity of the orchard.

DISEASES OF GARDEN CROPS

Club root. This root disease of turnips, cabbage, cauliflower, etc., is due to the slime-fungus *Plasmodiophora Brassicae,* Its character and history in Vermont have been discussed in detail in a former bulletin.[1] It was reported from new localities last summer and is apparently becoming more common each year in this vicinity. Doubtless this is in a considerable measure due to the setting of infected seedling plants. Precautions should be taken by those growing or purchasing seedlings to avoid this danger since the fungus persists indefinitely in the soil after it its once introduced.

Black rot of cabbage. This is a bacterial disease, due to *Pseudomonas campestris,* and likewise fully discussed in the bulletin just referred to. It also was common in this vicinity in 1906 and apparently is widespread in Vermont. No satisfactory remedy has been proposed other than rotation of crops, and such measures as aim to keep the plants free from insects which are carriers of the disease.

The bean anthracnose. This spot disease of the pods, commonly known as rust, is caused by the fungus *Colletotrichum Lindemuthianum.* It is common and often seriously destructive wherever beans are grown. The farmers of Grand Isle county and along the northern shores of Lake Champlain often devote considerable acreages to this crop and the disease may reduce the profits therefrom very materially as occurred in 1906. It is of practical interest, therefore, to call attention to two facts. First, that the disease is perpetuated through the seed, beans from spotted pods often

[1] Vt. Sta. Bul. 66, p. 5 (1898).

showing discolored spots which are fungus infested. Hence only clean unspotted seed should be used, and, if practicable, it should be derived from plants which were not attacked by the disease. Second, that spraying with bordeaux mixture greatly reduces the injury. This has been shown experimentally at the New York station; and at least one Vermont bean grower, Mr. E. S. Brigham of St. Albans, practiced such spraying with much profit in 1906.

Another disease somewhat similar in its effects upon the pods occurs and was fairly common about Burlington last year. This is the bacterial disease due to *Bacillus phaseoli*. So far as observed, however, its damage is of minor importance.

Violet leaf spot. A new violet leaf spot disease (*Marsonia violae*[1]) was received from President Ezra Brainerd of Middlebury,

FIGURE 1. Violet leaf diseased with *Marsonia violae*. The small black spots, acervuli, are often even more thickly clustered than here shown. (Natural size).

Vt., and specimens were also received through this Middlebury correspondent from Lyme, Conn. This may have been imported originally from Europe, since it has been known there for some

[1]For the identification of this fungus we are indebted to Mrs. F. M. Patterson, Bu. Pl. Ind., U. S. Dept. Agr.

time, but has only recently been seen in this country. The disease is characterized by numerous small, raised spots black or brown in color and occurring mostly upon the upper surface of the leaf. These little pustules, the acervuli, contain some curved, two celled spores averaging about 16 microns long by 5.5 broad. The septum is generally excentric, that is nearer

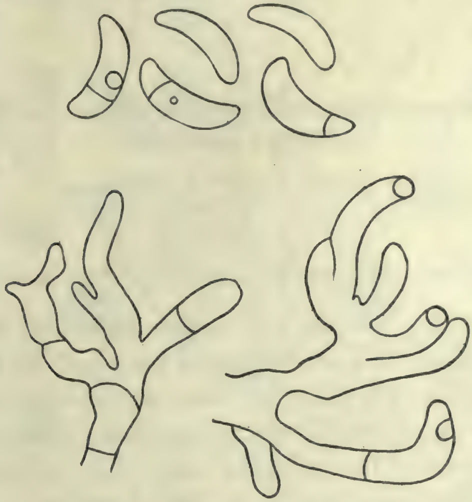

FIGURE 2. Spores and sporophores of *Marsonia violae*. Two non-septate, immature spores are shown. Oil globules and spores in process of formation are best shown at right. Magnified 750 times.

one end than the other of the spore. The disease attacks only the leaves of the plants and is not thought to be very dangerous, but it is quite evidently spreading and should be closely watched. The only remedy known at present is to keep the beds as free as possible from diseased leaves and plants.

Other diseases reported as occurring and locally troublesome are Tomato leaf blight (*Septoria Lycopersici*); Cucumber scab (*Cladosporium cucumerinum*); Onion mildew (*Peronospora Schleideniana*); Oat and corn smut (*Ustilago Mays Zeae* and *U. Avenae*); and Grape mildew (*Plasmopara viticola*). The point

rot of the tomato was unusually troublesome to certain local market gardeners on light soils. The exact cause of this is as yet unsettled, some regarding it as primarily physiological and others as due to bacterial infection. Attention to general cultural conditions, especially such as will insure an adequate and uniform supply of moisture to the plants is the only remedial measure as yet to be recommended with confidence.

THE LEAF BLOTCH DISEASE OF THE POTATO CAUSED BY CERCOSPORA CONCORS

L. R. JONES AND C. S. POMEROY [1]

OCCURRENCE AND CHARACTERS OF THE DISEASE

Introductory. In the last annual report of this Station[2] mention was made of a leaf blight of the potato of a nature not before recorded in this country. Since its appearance but shortly antedated the publication of that report, time did not then permit its careful study. This has since been made, the details of the work being chiefly in charge of the junior writer while a student in the botanical laboratory of the University of Vermont.

The appearance of the disease in 1905.[3] In the summer of 1905 the senior writer had under observation a plat of early planted potatoes of the Early Rose type. These were on a fairly rich old garden soil where it is probable that potatoes had frequently been grown before, although its previous history in this respect was not obtainable. About July 1, when the plants were in early blossom, it was noticed that the lower leaves showed

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[1] The authors are indebted to the officers of the Bureau of Plant Industry, U. S. Dept. Agriculture, for numerous courtesies offered in connection with this study, including access to herbarium specimens and the loan of books.

[2] A numbered list of the previous writings concerning this fungus appears at the close of this article. The numbers given in parenthesis in the text refer to this bibliography.

[3] Adapted from that inserted in the last report (page 271).

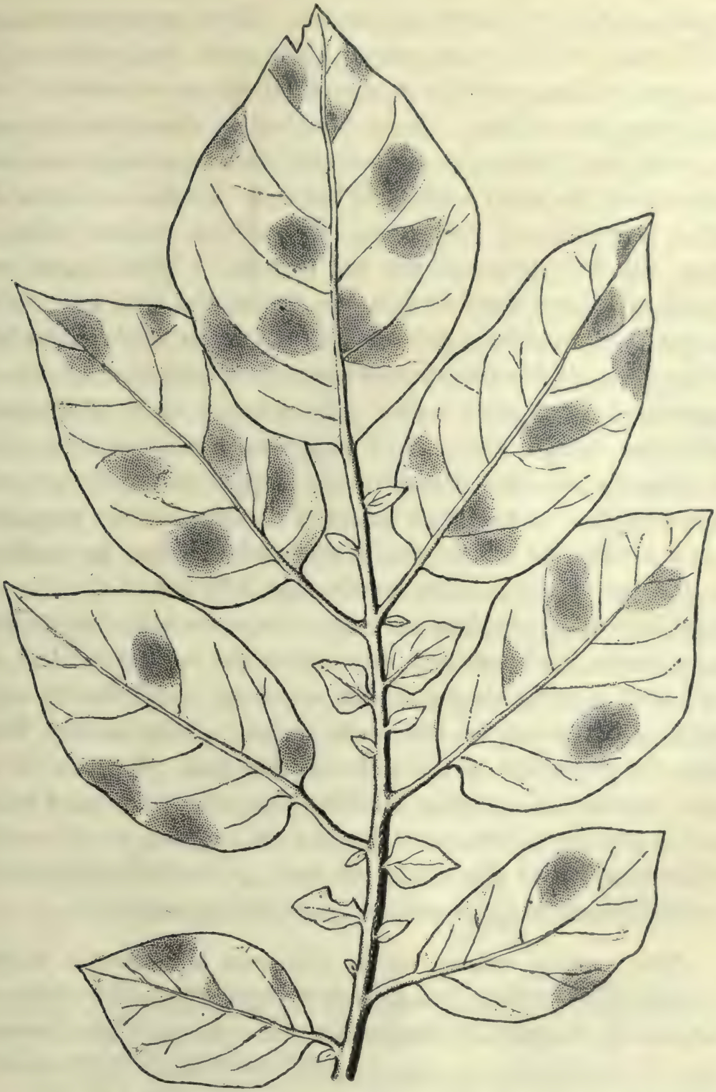

FIGURE 3. Potato Leaf Blotch, (*Cercospora concors*), showing natural size and distribution of the spots in the early stages of the disease.

numerous rather obscurely defined pale spots one-eighth to three-eighths of an inch (3 to 10 millimeters) in diameter, some-

times merging into larger aggregates. Their appearance was so unlike early blight or any other of the potato leaf spot troubles common at that season as at once to arrest the attention of one observing these things. Closer examination showed a pale gray or violet gray fungus growth covering these spots and most conspicuous on the lower surface of the leaf. Discussion of the detailed characters of the fungus, *Cercospora concors,* (Casp.) Sacc. will be postponed for the present. These spots continued to enlarge somewhat in size during the next two weeks, so that by the middle of July most of the leaves on the lower half of the plants of this plot showed the malady and some spots were apparent on the upper leaves. These began their development while the foliage was still of a normal green color, thus indicating the parasitic nature of the fungus; but their progress from the lower to the upper leaves of the stem further suggested that it attacks the foliage chiefly when it has passed its condition of greatest vigor—in other words, that it is one of the class of fungi known as weakling parasites. In some cases the invaded spots slowly blackened and died, while the rest of the leaf remained of a yellowish green, thus appearing much like the early blight spots caused by *Alternaria Solani.* More usually, however, the entire leaf slowly yellowed and died. In some of the latter there was the peculiar condition that the area invaded by the fungus was the last to perish—and even retained its chlorophyl rather longer than the rest of the leaf. A further discussion of the significance of these various symptoms appears later.

The spotting spread during July over an unknown variety of early potatoes lying immediately alongside these first infected, and during August and September there was a slight development of the fungus on several other varieties of late potatoes which were a few rods further removed. The damage on these later potatoes was quite insignificant, but upon the earlier ones it was considerable. There was no way of measuring this with exactness, but it was estimated to be equivalent to a mild

attack of early blight[1] and reduced the yield by, perhaps, one-fourth through sapping the vitality of the plants and leading to the earlier death of the foliage generally.

Other Occurrence in Vermont. This disease was not seen elsewhere in 1905. This is the more significant when it is noted that careful search was made on the extensive collection of European and American varieties of potatoes grown by the Horticultural Department. At the time of the earlier note (11) it was stated accordingly that this was the first and only occurrence of this disease in America known to us.[2] During the course of the subsequent studies occasion was taken to re-examine some spotted potato leaves collected by the senior writer at Huntington, Vt., July 18, 1902, and it was found to be a case of the same trouble. These leaves were taken from a garden plot in an old orchard, which had probably often before been planted to potatoes. The diseases was recorded at the time as "common and threatening to become seriously destructive."

In 1906 watch was kept for the appearance of the fungus. Part of the same area where it developed in 1905 was again planted with potatoes this season. A dozen tomato plants were also grown there. Several varieties of potatoes were included to test their relative disease resistance and the detailed observations along this line will be discussed later. Suffice it to say here that none of the fungus appeared on the tomato plants, but on July 10 the spotting by it was apparent on Early Rose and Early Ohio potatoes which had been planted May 19. The course of the disease was much as in 1905, appearing somewhat later on

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[1] Early blight, *Alternaria Solani,* did not occur on either of these plots. There was a very little of the late blight due to *Phytopthora infestans*, but this came considerably later in the season and was easily distinguished from the spotting caused by the *Cercospora.*

[2] There is a specimen in the herbarium of the United States Department of Agriculture collected by A. B. Langlois in Louisiana, 1888 (apparently at St. Martin, May 1, but this data is not clear) and labelled by him as *Cercospora concors.* We have had opportunity to compare this with the authentic series of European specimens also in the Department herbarium and find it to be altogether different from these both in macroscopic and miscroscopic characters. We have not attempted to decide what it is, but it certainly is not *Cercospora concors* (Casp.) Sacc.

the balance of the potatoes, which was to be expected since they were medium and late varieties and planted about a week later than the above. The fungus was not as general and destructive in its occurrence as in 1905. Search again failed to reveal it on the trial plots of potatoes grown by the Horticultural Department. Examination of a field of early potatoes, again in an old orchard adjacent to the Experiment farm, showed it to occur sparingly there on the Puritan variety.

These observations, coupled with what will follow as to its occurrence in Europe, lead the writers to judge that this fungus will be found to occur frequently in this section. It has been seen three seasons and in three different places. Moreover all were on long tilled lands which had evidently been used for potatoes before and in one case it was observed two years in succession on the same ground. There is no reason to believe, in view of these facts, that this is any recently introduced or "new" disease. Its occurrence at the same season as the other fungus leaf blights and the general similarity of the injury it inflicts to those which follow their attacks, and especially those of the early blight, have doubtless led to its being overlooked or confused with those maladies. Indeed, from either the economical or the practical point of view there is little reason for careful discrimination between the *Cercospora* and the *Alternaria* diseases. They cause similar damage at about the same season and the remedial measures are alike. It is believed, however, that further observations will reveal some difference as to the favorite habitats of the two. The early blight (*Alternaria*) thrives best on warm, rather dry, sandy soils and in the dryer, hotter seasons. This *Cercospora* on the other hand, according to the limited observations thus far made, prefers rich soil and more moisture with slight shade, while dry hot weather tends to check its spread. It is believed, therefore, that in contrast with the *Alternaria* which occurs more destructively south and west than in northern New England this *Cercospora* will be found more commonly northward. The

writers will be surprised if it occurs at all south or west of New York.

Occurrence in Europe. Following the determination of the identity of the species with Caspary's *Cercospora concors* a careful search was made through European literature. The recorded history of the fungus extends back a half century as follows: It was first observed July 27, 1854, at Schoeneberg, a suburb of Berlin, Germany, by Dr. Robert Caspary (1) on the living leaves of potato. He described it in the article already referred to as *Fusisporium concors,* noting two forms of spores to be described later and choosing the specific name *concors* because in the earlier stages of its attack it does not appear to injure the potato leaves. Specimens of the fungus found by Caspary were distributed by Klotzsch[1].

Frank (2) in 1880 makes mention of the fungus and from his studies upon it, without, however, having seen Caspary's original article, transferred it to the genus *Ramularia.* Sorauer (3) catalogues it under the name *Ramularia concors* as one of the fungi inhabiting living potato leaves. It is noteworthy that in Frank's later publication[2] no mention of this fungus appears. Saccardo (4) in 1886 classified it as a *Cercospora,* the name now accepted. Up to this time the fungus had apparently been collected by no botanist except Caspary.

Krieger found it in 1887 at Königstein in Saxony on July 8. He also made collections of it at Schwarzenberg and later at Königstein. From these stations it was distributed by Rabenhorst[3] and also by Krieger[4] and in the publication accompanying his last mentioned distribution Krieger (5) gives a brief description of the fungus containing some alterations from Saccardo's description.

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[1] Klotzsch. Herbarium viv. mycologicum No. 277.

[2] Frank, A. B. Kampfbuch gegen die Schadlinge unserer Feldfruchte (Berlin, 1897).

[3] Rabenhorst, Fungi Europaei, No. 3790.

[4] Krieger, W., Fungi Saxonici, No. 300; Schadlich Pilze unserer Kulturgewachse, No. 42.

Allescher (6) found the fungus in abundance, epidemic in potato fields near Oberammergau, Bavaria, in July and August, 1893.[1] Bubak (7) reported it to be widespread in Bohemia in 1901. Jaczewski (10) discovered it in Russia in 1900 and in 1903 reported it from three rather widely separated provinces of central and northwestern Russia. Lindroth (8) reports the destructive occurrence of this disease upon potatoes from Finland in 1902.

By far the most searching inquiries into its occurrence and the damage done by it have been made during the last decade by Lagerheim and Wagner. The results of these studies, together with a critical account of the fungus, have been recently published by them (9) together with a review of previous literature. Wagner reports having found the fungus in several places in Germany and Switzerland during 1892, 1893, 1895, 1899, 1900, 1901, 1902. Generally it was first observed in July and persisted in some cases through the rest of the season. Lagerheim found it in Uppland, Sweden, in 1902.[2] Here it spread rapidly in the last of August and killed a piece of potatoes of the variety Red American. They quote Saccardo as saying that the fungus does not occur in Italy.

From these accounts it would at first thought appear that the fungus is sporadic and somewhat irregular in its occurrence. Those who have studied it carefully believe, however, that it is quite general in the infected areas of Europe, but that it has been overlooked because of its resemblance to *Phytophthora infestans.* An examination of the above records reveals the noteworthy fact that its distribution is chiefly in the north of Europe and that at its southern limits it occurs at high elevations in Bavaria and Switzerland. It does not even go as far south as *Phytophthora* which occurs in Italy.

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[1] A distribution of this collection was made by Allescher & Schnabl, Fungi Bavarici, No. 399.

[2] He distributed specimens of this as No. 617, Vestergren, Micromycetes rariores selecti.

As already noted, this fact coupled with the observations as to its occurrence in Vermont leads one to expect its distribution in this country to be limited to the Northeastern States and Canada.

DETAILED STUDIES OF THE FUNGUS

Its identity. Since the fungus was a stranger to the writers, specimens of it were sent when first collected to W. A. Orton of the Bureau of Plant Industry of the Department of Agriculture for advice. He confirmed the judgment that it was a fungus heretofore unobserved as a potato parasite in this country and kindly referred the writers to certain European observations on *Cercospora concors* and allied fungi. Careful laboratory and herbarium studies have since been made by the writers which have shown that the fungus is, as already stated, the species *Cercospora concors* (Casp.) Sacc. It not only is in general agreement with the published accounts of this fungus, but comparison with the European exsiccati already referred to shows it to be identical therewith.

A number of species of *Cercospora* have been described both in this country and Europe on potato and allied solanaceous plants. Since the fungi of this class are but imperfectly understood their possible interrelations are matters of scientific as well as economic interest. Is the fungus in question a native on some solanaceous host; or has it come to us on the potato from foreign parts? No evidence touching this matter is offered except that no *Cercospora* has been collected on allied hosts in Vermont and that no solanaceous weed has been found in the vicinity of the fields where this fungus has occurred. Moreover, a careful comparison with all the descriptions and such herbarium specimens as could be secured does not lead the writers to ally this with any of the other described species.

As already noted it did not appear upon tomatoes grown on infected soil in 1906, although it freely attacked potatoes growing alongside. So far as the evidence goes, therefore, it indi-

cates that the potato is the only host of this fungus and hence that it was introduced with this host presumably from Europe.

Saccardo's (4) brief description of the fungus has already been referred to. The detailed characters were worked out and described by Caspary (1) and later by Krieger (5), Lagerheim and Wagner (9). The laboratory studies at this Station have in general confirmed these observations.

The fungus first shows upon the living leaves as rather indistinct pale-gray or violet-gray spots on the lower surface. Their presence is generally indicated by a slight paling over the corresponding area above and this spot in the more rapid developments soon dies and blackens. In other cases the fungus pushes through the stomata above also and forms a growth having a similar appearance to that of the lower surface, except that it is less abundant. Examined under the microscope the behavior of the fungus on the two surfaces is considerably different. On the upper side tufts of erect and unbranched somewhat brown septate hyphae push from the stomata to a height of 40-80 microns and a single conidium is borne on the top of each. (See Fig. 5, p. 248). On the lower surface fewer branches may protrude from each stoma, but they develop much more vigorously often extending out several hundred microns, and branching frequently. They may stand out more or less erect or ascending from the surface, but as a rule they recline or creep along the leaf surface or climb up the hairs which they may in this way completely overgrow and even cause to bend or curl at the end. (Fig. 5). No hyphae have been observed penetrating the epidermis other than through the stomata.

Conidia are borne in abundance especially on the lower leaf surface. The variety in their form and septation is greater than Saccardo's description, already quoted, would indicate. (See numbers 1 and 2, figure 5, p. 248). They are thin walled, nearly colorless, either one-celled or having 1-5 septa. They vary in size from 15-90 by 4-6 microns. In general the diameters were 4-5 rather than 3-4 as Saccardo states, in this respect agreeing

more nearly with Krieger's description (5). Measurements were made of lengths of 500 conidia taken from four different leaves and the results are tabulated below. While these show extremes varying from 15 to 90 microns about 98% fall within the limit of 18-63 microns and nearly 75% lie between 20-50 microns. The internal hyphae in advanced stages develop bead-like swelling or chlamydospores which Caspary first (1) clearly described. These are discussed later as they appeared in the station cultures. The writers' observations accord with those of Lagerheim and Wagner (9) that the mycelium within the leaf is strictly intercellular.

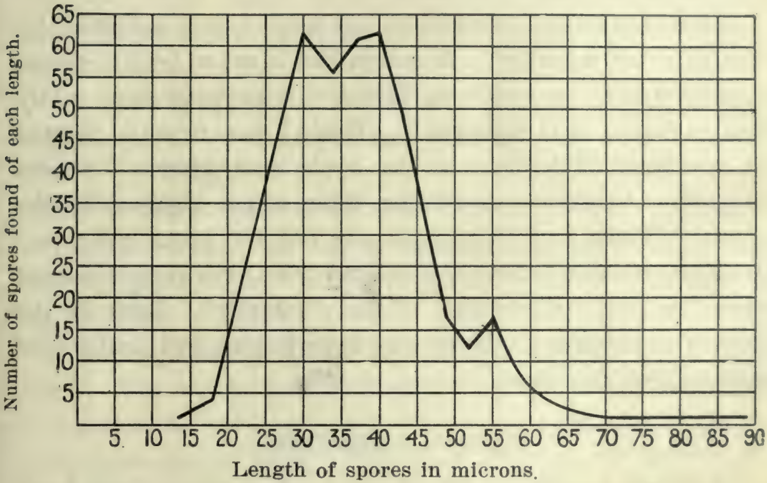

FIGURE 4. Curve plotted to show the characteristic lengths of spores of *Cercospora concors*. Measurements were made of 500 spores freshly taken from four potato leaves. It will be seen that while the extreme lengths range from about 15 to 90 microns, but few spores were found less than 20 or more than 50 microns and the majority were from 25 to 45 microns long.

An interesting relation of fungus to host was first described by Caspary (1). It is that in the earlier stages of the attack the fungus may cause no marked derangement of functions in the leaf tissues. According to observations made here what change does occur seems rather in the way of stimulating the normal leaf activities as manifested by a persistence of chlorophyll in

the fungus inhabited areas. In its later stages or in more virulent attacks the fungus behaves as an active parasite and the invaded tissues are discolored and die, the spots often appearing much like those killed by the early blight fungus (*Alternaria Solani*). Caspary pointed out that in the earlier stage the fungus is producing its aerial conidia in abundance, but that in the later one the reproductive processes are directed to the increased development of the mycelium within the leaf tissues and finally conversion of this into bead-like chains of chlamydospores. Caspary's original figure illustrative of this point is reproduced on page 248.

Such temporary stimulation of host tissue activities by parasites is not infrequent, of course, and is not to be interpreted as saprophytism or symbiosis although it suggests how subtly these processes may intergrade. Heald[1] has recently pointed out a similar dual effect of the apple scab fungus *Venturia inaequalis*. In early summer the apple leaves attacked by the fungus yellowed and fell prematured but the green color persisted longest in the fungus inhabited areas, the fungus having induced a local conservation of the chlorophyll. Later in the season the invaded tissue showed hypertrophy and finally died in advance of the others.

CULTURAL CHARACTERS

Attempts to cultivate the fungus on the ordinary beef broth media met with poor success, but it has grown well on certain synthetic and vegetable substrata. The best developments have been secured on a synthetic agar medium[2] made as follows:

Dextrose, 100 grams; Witte's peptone, 20 grams; ammonium nitrate, 10 grams; potassium nitrate, 5 grams; magnesium sulfate crystals, 2.5 grams; potassium phosphate, 2.5 grams; calcium chlorid, 0.1 gram dissolved in 150 c.c water; agar-

[1] Heald, F. D. Nebr. Sta. Rpt. 19, p. 25 (1905).

[2] Adapted from that recommended by Darwin and Acton. Physiology of Plants, p. 60 (1894).

agar, 15 grams; autoclaved in 1000 c. c. of water for 1 hour under 13 pounds pressure; the two solutions then mixed, cooled to 67° C., the beaten white of one egg added, cooked for 15 minutes in double boiler, filtered through absorbent cotton tubed and sterilized in autoclave, 15 minutes at 15 pounds pressure. This medium is quite strongly acid, titrating with the chemicals used about + 80, Fuller's scale.

Pure cultures were obtained by the poured plate method from two leaves, the growth from a single spore being followed in each case. All subsequent cultural studies were carried on in duplicate series using these two strains. The developments have, however, proved identical, hence are not discussed separately.

Conidia germinate within 24 and 48 hours in poured plates of this agar at room temperature (18°-22° C.). This is a slow growth as compared with most fungi, and it continues but slowly so that at the end of a week the colonies are barely visible to the naked eye. So far as observed the conidia germinate only by growth from one or both end cells as shown in the figures.

The mycelium produced is abundantly septate and branches freely. The surface growth during the first two or three weeks is almost white, but later it darkens to an ash gray and finally this deepens to almost black. The early growth may spread as a thick circular mat for a short time but very soon the chief development changes from this lateral extension to a thickening into a much wrinkled and corrugated mass somewhat resembling brain coral in configuration. This manner of growth continues slowly until the dessication of the medium checks it and the masses have ultimately reached a size of from 1 to 2.5 cm. in diameter in culture tubes.

Examined under the microscope this darker mass is seen to be composed wholly of rounded thick walled cells or chlamydospores. (See 4, 7-11, fig. 5, p. 248). These vary considerably in size, being from 8-18 microns in diameter, nearly circular in

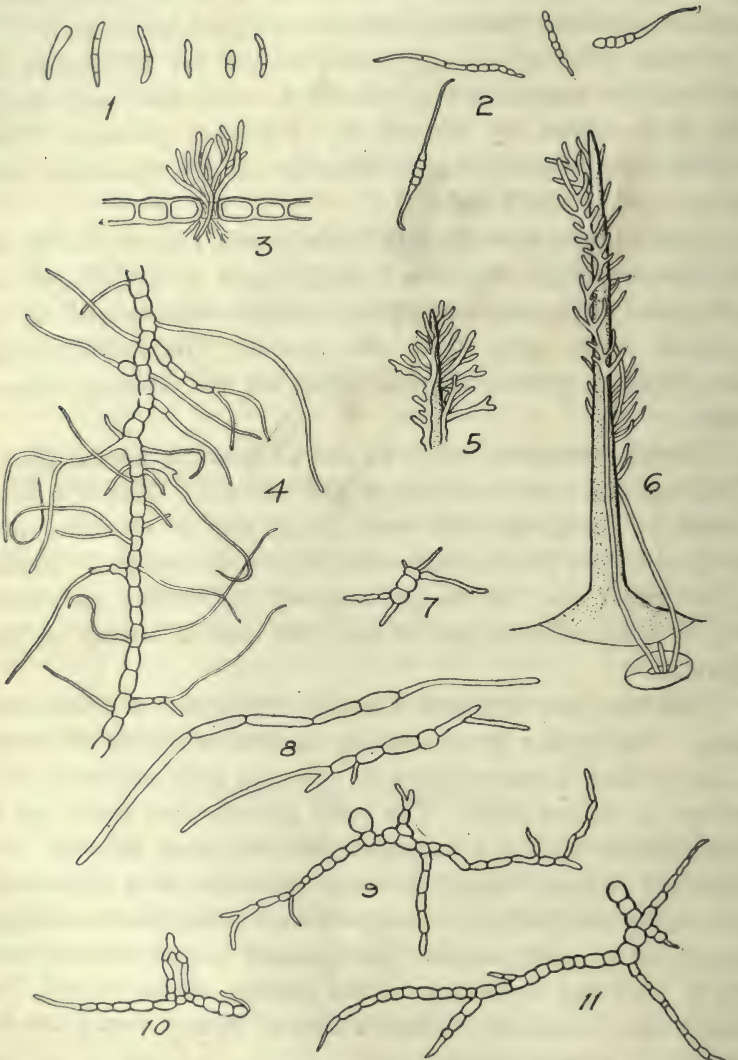

FIGURE 5. Drawings of the Potato Leaf Blotch fungus *Cercospora concors,* magnified 200 times.

1. Conidia from potato leaf, showing variations in size and septation.
2. Conidia in early stages of germination.
3. Section through a bit of the lower epidermis of an infected potato leaf, showing emergence of the conidiophores through a breathing pore and the formation of conidia.

4. Mycelial growth from near the edge of a culture one week old in synthetic agar. The central thread shows an early stage of chlamydospore formation.

5 and 6. Show how hyphae emerging from the breathing pores may twine about the leaf hairs..

7 to 11. Germination of detached chlamydospores on synthetic agar and progressive stages in the development of further chlamydospores, many of which are fully matured in No. 11.

outline, thick-walled, dark brown, rich in oil and evidently capable of lying dormant for an indefinite period. If transferred to fresh agar, however, these chlamydospores germinate promptly, usually sending out a germ tube from two sides as shown on the opposite page. This growth proceeds as from the conidia; the mycelium being at first thin walled, light-colored, multiseptate, branching freely, and with numerous oil drops. After a few days the older parts show thickening walls, of darker color, the cells being short-rectangular with slight median constrictions. Meanwhile the oil collects as two droplets, one in either end, and a partition wall develops at the point of constriction forming two more or less spherical chlamydospores each containing one oil drop. This development proceeds with the transition from the younger to the older parts as long as growth continues.

As already noted similar chlamydospores were found by Caspary to occur in the interior of the older spots on potato leaves. Apparently, therefore, it is the state in which the fungus passes the winter.

No further developments of any kind either as to mycelial structures or spores have been secured on this or other culture medium, although such have been carefully watched for and under quite wide temperature variations. The latter have included the storing of old tube cultures for the three winter months in a room when the temperature often fell below the freezing point. Of course these remained dormant meanwhile, but when transfers were made from them at the end of the period growth occurred exactly as with the ordinary younger material.

COMPARATIVE GROWTHS ON VARIOUS MEDIA

The best growth being obtained on the synthetic agar, as already described, that was used as a basis for the further comparative studies. Summarizing what has already been said regarding the growth on this synthetic agar it is to be noted that the growth is practically confined to the surface of the medium. It is at first white, but after two or three weeks gradually passes through an ashy gray to a dark gray color on the surface, the underlying mycelium meanwhile becoming almost black.

The lighter colored surface growth is thin walled, the blackening is associated with the transformation of the mycelium into bead-like chains of thicker walled chlamydospores. The growth proceeds within more rapidly than at the margins and so it not only thickens or heaps up at the center, but irregular folds and corrugations soon appear giving in tube cultures wrinkled colonies 1 or 2 cm. across. No reproductive bodies other than chlamydospores have been observed in these or other cultures.

Prune agar.[1] Growth slightly slower than on the synthetic agar above described, and darker in color, even the earlier growth not having the white or gray color, except that the tips of long free growing hyphae were sometimes gray.

Potato agar.[2] Growth fair but distinctly less rapid than on either of the two agars already described: color dark as in prune agar; growth extended somewhat into the medium.

Beef broth agar.[3] Growth very slow and soon ceasing altogether. Medium browned.

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[1] One-half pound dried prunes, water sufficient to cover, boiled one-half hour and extract filtered. Agar 7.5 grams, in 500 c.c. water, autoclaved one hour at 15 lbs. pressure. Added prune extract to this, cooled to 65° C., added white one egg, cooked 15 minutes in double boiler, added water to make 500 c.c., final sterilization in steamer.

[2] Freshly dug potatoes, washed, pared and sliced. Added 2000 c.c. water to 1500 grams potatoes, cooked one and one-half hours in double boiler, strained and filtered through absorbent cotton. To 1500 c.c. of this extract added 1 percent agar, which had been previously autoclaved, cooled to 45° C., added whites two eggs, cooked one-half hour, filtered; final sterilization in steamer.

[3] Prepared from Liebig's beef extract with 1½ percent agar by usual methods, reaction neutral to phenolpthalein.

Beef broth.[1] Spores would not germinate.

Cooked potato.[2] A somewhat better medium than the potato agar, but not equal to the prune or synthetic agar. New growth white becoming gray and black with age. It extended into the potato tissue and chlamydospores were produced in abundance within as upon the surface.

Raw potato.[3] No growth; even when liberal inoculations of mycelial masses were made these merely dried and blackened without increase in size.

Cooked beet. Growth slight, only about one-half that of cooked potato; surface mycelium at first light colored, later darkening.

Raw beet. Same growth but less than on cooked beet. It was noteworthy, however, that this proved a better medium than raw potato as shown not only by growth at the point of innoculation but also by the later starting of new colonies from the scattered chlamydospores.

Cooked turnip. Growth about as on cooked beet.

Raw turnip. No growth. That this was due to the unfavorable medium was shown by again lifting the bits of fungus which had lain dormant on the raw turnip several days and transferring them to fresh synthetic agar tubes, when they at once resumed growth.

Cooked carrot. Growth about as extensive as in cooked potato but darker in color.

Raw carrot. No growth although test transfers as described for raw turnip showed the mycelium to be alive.

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[1] From Liebig's extract, neutral to phenolpthalein.

[2] Cylinders cut from flesh of a fresh potato tuber, placed in test tubes with a bit of absorbent cotton in the bottom, ½ c.c. of water added, i. e., enough to immerse the base of the vegetable cylinder, cooked and sterilized in the steamer. The other cooked vegetables were prepared in the same way, viz.: roots of beet, turnip and carrot.

[3] Cylinders cut, with precautions to insure sterility, from fresh living potato tubers, inserted in sterile tubes containing water enough to cover the base of the vegetable cylinder, i. e., ½ c.c. The other raw vegetables mentioned were prepared in the same way.

Comparing these cultural developments it is seen that a considerable growth occurred on all cooked vegetables, whereas none whatever was secured on raw vegetables other than beet and on this it was distinctly less than on the cooked beet. In all cases where growth occurred there was absence of conidia and rapid transformation of the entire mycelial mass into chlamydospores. These results indicate that no development of the fungus occurs upon or in potato tubers or other living vegetable roots in the field or storage. It is, however, probable as indicated by the prompt development on cooked vegetables that the fungus grows saprophytically on dead vegetable tissues of various kinds and produces chlamydospores thereon. It may thus be perpetuated and even increased indefinitely in soil rich in decaying vegetable matter when once introduced. This is significant in the light of its occurrence in rich old gardens in all three cases where the writers have found it.

TEMPERATURE RELATIONS

All cultures unless otherwise specified have been kept at laboratory room temperature, 15°-22° C. To determine its temperature relations special cultures were carried at lower and higher points with the following results.

No growth has occurred below 8° C. Cultures held at 8°-12° C. grew somewhat, but much slower than others at 18°-25° C. There was some evidence that the growth was more rapid near the upper of these limits. At 37° C. no growth occurred but this may be in part due to the more rapid desiccation of the surface of the medium at this higher temperature.

Tubes stored for some three months in an unheated room in winter where the temperature ranged 0° C. to 10° C. were not affected in any perceptible way. Growth was, of course, checked during this period but when transfers were made to fresh media and these held at 18°-20° C. growth was immediately resumed.

INOCULATION EXPERIMENTS

The observations already recorded make it evident that the fungus is a parasite. So far as learned, however, none of the investigators who have previously studied it have attempted inoculation experiments. Soon after it was first observed here, viz.: the first of August, 1905, such were undertaken as follows: A leaf bearing an abundance of spores was rinsed in a shallow dish of water. The hill of potatoes to be inoculated was then covered with a barrel from which both heads had been removed, the plants sprinkled with water and then the spore-containing water scattered over the moist foliage. Finally a cover was placed over the barrel and it was left undisturbed until the next morning, when the barrel was removed. One hill of each of seven different varieties was treated in this way, including Richter's Imperator, Keeper, Irish Cobbler, Dakota Red, Blight Proof, Royal Kidney and Eldorado. Only one of these showed positive results, viz.: Richter's Imperator. Fungus bearing spots became apparent to the naked eye on the inoculated hill of this variety about three weeks after the inoculation. A little later the fungus was evident on the two hills of this same variety immediately adjacent to the inoculated plant in the same row. These results are not conclusive since these rows were in another part of the same general field where the *Cercospora* was occurring spontaneously. There seemed no reasonable doubt, however, that the infection in the case of the Richter's Imperator resulted from the inoculation and that the three weeks' interim represented the period necessary for the development of the fungus under those conditions. The failure upon the other varieties was in harmony with other observations recorded later, which show that there is a well marked difference in the relative susceptibility of varieties and that some, at least, of those inoculated are resistant to this fungus.

REMEDIAL MEASURES

Spraying. Lagerheim and Wagner recommend bordeaux mixture spraying as a preventive. Fortunately it comes at about

the season of the early-blight fungus and may, therefore, be held in check by proper spraying as now directed against this and the late blight fungus. We have not had opportunity to demonstrate the effects of spraying, but are confident that this treatment will prove efficient.

The only other detail to be noted under this head is the matter of relative resistance shown by varieties.

Disease resistance of varieties. Attention has been given to this question in connection with the other observations. The outbreak in July, 1905, was on Early Rose, which has proved one of the most susceptible varieties. In another part of the same field in 1905 a number of varieties were under trial, these having been planted some three weeks later than the Early Rose. The fungus appeared on these in the latter part of August. Some of the earliest were dead or practically so before this time, hence no account is taken of them. The following were, however, in fairly vigorous condition up to September first and the following notes taken the later part of August may, therefore, be interpreted as indicative of relative liability to the fungus.

Free from the fungus: Dakota Red, Delaware, Blight-Proof, Rural Blush, Evergood, Factor.

In contrast with these considerable *Cercospora* was found on Holborn Abundance and on Professor Maerker and still more on Swiss Snowflake. As already noted it was secured by inoculation upon Richter's Imperator also.

This difference was especially significant in that the four varieties attacked were not in contiguous rows in any case, but were distributed with immune varieties separating them.

For further observation along this line plantings were made in 1906 as follows on the soil where the disease was worst in 1905. May 18: Early Rose and Early Ohio. May 26: Delaware, Holborn Abundance, Blight Proof, Rural New Yorker No. 2, Rural Blush, Swiss Snowflake, Eldorado, Labergeries so-called violet variety of *S. Commersonii.*

As already noted *Cercospora* appeared early in July upon the Early Rose and Early Ohio and progressed about as in 1905, but rather less destructively. About two weeks later the fungus development was well marked on certain of the later varieties and on these ran its usual course. Others of them although in adjacent rows and with intermingled foliage remained throughout the season free from the fungus. That their relative position and susceptibility may be clearer we repeat the names in order of position in the plot with notes on the occurrence of the fungus:

1.	Early Ohio,	Occurrence of *Cercospora*:	Much.
2.	Early Rose,	" " "	Much.
3.	Delaware,	" " "	None whatever.
4.	Holborn Abund.,	" " "	Much.
5.	Blight Proof,	" " "	A small amount.
6.	Rural N. Y. No. 2,	" " "	Practically none (one leaf).
7.	Rural Blush,	" " "	None whatever.
8.	Swiss Snowflake,	" " "	Much.
9.	Eldorado,	" " "	None.
10.	Labergerie's var'y,	" " "	None.

Less importance should be attached to the outcome with the last two varieties, Eldorado and Lebergerie's, than with the others as there were only three plants of each. In the case of the others mentioned these results are in substantial agreement with the preliminary observations of 1905, so far as the same varieties were included both seasons. The outcome seems, therefore, to justify the conclusion that there are well marked varietal differences as to disease resistance; that certain varieties, including Delaware and Rural Blush, are nearly if not quite fully resistant; that certain other varieties show but slight susceptibilty; and that some, including Early Rose, Early Ohio, among the earlier varieties and Swiss Snowflake, Holborn Abundance and Professor Maerker among the later ones are especially liable to attack.

It is of farther interest to note that the three varieties upon which the fungus appeared spontaneously were of the same general habit and foliage type and this a clearly marked one. All are strong erect growers, above average height, leaves rather large, rugose, pubescent and having a lighter and slightly grayish tint as compared with most other varieties. This color is, however, apparently due to the texture of the leaf and the number and character of the hairs borne on them rather than to less chlorophyll contents. It was noteworthy that these same varieties were relatively less eaten by the flea-beetles than were the others. Blight Proof was, however, of this same general habit and type and while also less eaten by the insects it was nearly free from *Cercospora.*

European reports indicate well marked differences in varietal susceptibility as reported upon by the various writers. Allescher (6) found it worst on the Rose varieties. Wagner (9) reports varietal differences also, it being found on Champignon, Magnum Bonum and Reichs Kanzler in Germany, the occurrence on Magnum Bonum being noted in several places. It is worthy of recall in this connection that this variety is a hybrid having Early Rose for one parent (Early Rose X Victoria).

Lagerheim (9) states that in Sweden upon the variety known as Red American it spread rapidly and entirely killed it, whereas it was not found on another field, apparently of a more resistant variety, separated from the first only by a narrow path.

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THE BLACK LEG DISEASE OF THE POTATO

L. R. JONES

Reference was made in the last report to the black leg type of potato stem disease, although nothing of the sort was observed that year. In 1906, on the contrary, a considerable outbreak of this malady came under observation. Vague reports have frequently come to the Station in previous years as to troubles of this class; and the occurrence and symptoms as they appeared here in 1906 are described partly as a matter of record, and partly in the hope that it may lead correspondents to report

comparative observations on similar occurrences the coming summer.

Black leg, the *Schwarzbeinigkeit* of the Germans, is, as stated in the last report, a well marked potato disease, common in Europe and characterized by a soft rot of the base of the stem. It bears some likeness in symptoms to the potato rosette disease described by Selby as occurring in Ohio[1] and to certain stem diseases popularly termed "collar rot," "little potato disease," etc., in the Colorado potato sections[2] and in the south.[3]

The writer had opportunity to familiarize himself in 1904 with "black-leg" as it occurs on potatoes in Germany and England where it is a common malady.[4] He was accordingly on the outlook for it here in 1905 but saw none. Early in July, 1906, an outbreak of it appeared in one of the station fields and offered favorable opportunity to study its character and follow its development through the summer.

Since the trouble was confined to one field it seems worth while to describe the conditions occurring there. The soil was a strong heavy gravelly loam which had been well fertilized with stable manure in preceding years and received about 1000 pounds of commercial fertilizer this year. The field was planted with Green Mountain potatoes, the seed being from Houlton, Maine. This was apparently sound and was disinfected before planting by immersion for two hours in one-tenth percent solution of formalin as is commonly practiced to guard against scab.

The first symptoms of the malady attracted attention on July 12. The average plants were then about ten inches high, and none had reached the blossoming stage. The general appearance of the diseased plants was characteristic and in every

[1] Selby, A. D. Ohio Sta. Buls. 139, 145 (1903).

[2] Rolfs, F. M. and Paddock W., Colo. Sta. Buls. 70 (1902); 91, (1904); 92, (1904); and Press Bul. 26 (1906).

[3] Rolfs, F. M., Fla. Sta. Rpt., p. 42 (1905).

[4] See account L. R. Jones, U. S. Dept. Agr., Bu. Pl. Ind., Bul. 87, p. 17 (1905).

respect the same as occurs in Europe. Whatever one may think as to identity of cause, the symptoms, the appearance and the progress of the disease to the ultimate death of the plant were exactly the same as occur in the case of the German "Schwarzbeinigkeit," and the English "black-leg."[1]

The earliest conspicuous symptom was that the diseased plants were slightly below normal size, of a paler or yellowish-green color, the lateral branches and the leaf steams or petioles tending to become more erect and the leaf blades folding or curving slightly upward. As a result the entire plant had a narrowed aspect. The lower leaves had in many cases, by this time, partially shrivelled or died. Gently pulling up such a stem or better digging it up so as not to break it, revealed in every case the stem more or less fully browned or blackened from near the surface of the soil downward. In some extreme cases the discoloration was apparent for as much as an inch above the soil. This discoloration accompanied or was followed by the death and ultimate decay of the soft tissues of the stem. In all cases examined—and this was a larger number—the seed tuber was rotten and in many it had fully disintegrated leaving only portions of the skin. Several healthy plants dug at the same time showed the seed tuber still hard and untouched by decay. In most cases it was evident that the death and decay of the stem proceeded from the very base upward, that is it took its inception at or near the point of origin of the stem growth from the seed tuber. There were cases, however, where the disease had apparently first appeared in the tissues above the stem base. The death proceeded from the superficial or cortical layers, later involving the pith also in decay, and the wasting away of these

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[1] The best discussion of this disease as it occurs in Germany is that by Dr. Otto Appel. Arb. ans d. Biol. Abt. Kaisel. Gesund heitamte, III : 364-432 (1903). Frank also well describes it. Frank, A. Kampfbuch gegen die Schadl. unserer Feldfr. 212. There is no equally good account of its occurrence in England, although it is well known there under the name black-leg and stem rot. The author passed almost directly from German fields where it was prevalent to English fields and found the malady equally common and identical in appearance with that on the continent.

often left little more than the woody tissues at the base of the stem when the advanced stages of the trouble were reached. Often the decay of the pith had proceeded to as high or even a higher point than the surface cortical decay, but in no case was decay observed which seemed to have started in the pith in advance of that of the cortex. Our conclusions were, therefore, that the decay starts in the cortex and invades the pith regions later. There was no evidence of primary disease of the vascular bundles and in some cases there was no marked discoloration of the bundles. Frequently, however, the vascular areas were distinctly browned for some inches above the limits of decay of the soft tissues and in a few cases this browning even extended into the lower leaf stalks. The death of the roots seemed to be a secondary matter following the death of the stems. In some cases branch roots apparently healthy radiated from stems badly discolored. Ultimately all of the black-leg stalks slowly died, the long progress of the disease evidently being due to the persistent activity of the roots even while the base of the stem was dying. The foliage symptoms described above are explained as chiefly due to the gradual diminution of soil absorption consequent on the slowly progressing death of the base of the stem and the consequent cutting off of connection with the roots.

It was further noteworthy that it was the general rule that when one of the two or three stalks composing a hill—and all of which originated from the same tuber—was diseased all were affected, although not always to a like degree. There were frequently cases, however, where only one or two stalks were affected, the others remaining sound.

An average of several counts which were made during July and August showed that nearly one percent of the plants in this field were killed in this way, not a large loss, but sufficient to show how general the trouble was since these plants were well scattered. As stated before, the first cases were observed in the second week of July and by the first week of August

nearly all of the affected stalks were dead and there was but little further development of the trouble.

The writer is not as yet fully satisfied as to the cause of this trouble. As already stated somewhat similar, but not identical, maladies in other state have been attributed by Selby, Rolfs and others to the parasitism of the fungus commonly known as the potato *Rhizoctonia.* This is a fungus occurring widely, indeed according to our observations almost universally, on the underground part of potatoes. Ordinarily it is a surface saprophyte, but it has long been considered capable under favoring circumstances of functioning as a facultative parasite, or to use perhaps a better term, as a weakling parasite, i. e. capable of parasitism on tissues previously weakened by some other cause. No inoculation experiments have been carried on in this State, yet some of those[1] who have done so in America believe the results to be conclusive and the standard foreign textbooks on plant pathology subscribe to this teaching. Examination of the potatoes in the field in question showed that *Rhizoctonia* was quite generally present on the underground parts of the potato plants, but there was no marked difference as to the relative frequency or extent of its development on the diseased stems and on the healthy ones in adjacent hills. Moreover, this fungus was more constant in its occurrence and far more vigorous in its development upon the stems of the plant in another potato field under observation than it was anywhere in the field showing the black-leg—yet not a single typical case of black-leg was seen in this second field.[2] The potatoes were of the same variety at about the same stage in development. The writer is not of the opinion, therefore, that *Rhizoctonia* was the cause of this malady as it occurred here. He conceives that under other circumstances this fungus may be a primary or, at least, a con-

[1] Rolfs, Colo. Sta. Buls 70, (1902) ; 91, (1904).

[2] In this second field the fungus not only occurred as a felted network over the stems underground, but was observed several times as a gray growth extending an inch more or less above ground and richly covered with spores constituting the fruiting stage, known as *Corticium vagum var. Solani,* Burt.

tributary cause in bringing about similar troubles and would not by any means wish to draw a general conclusion from these limited observations which would be contradictory to those reached by Selby and Rolfs as a result of their more extensive observations and experimental studies upon the pathogenicity of this fungus. All he wishes to register is his opinion that in the present case the fundamental cause is to be sought elsewhere.

At least one other kind of fungus was frequently associated with the *Rhizoctonia* in the superficial tissues of these decaying stems and, of course, bacteria were abundant in the decaying tissues. Although considerable time was given to these organisms and pure cultures obtained of some of the bacteria, no satisfactory conclusions touching this matter have as yet been reached. Appel (loc. cit.) believes that black-leg (*Schwarzbeinigkeit*) as it occurs in Germany is primarily due to bacteria, *Bacillus phytophthorus* and other allied species, which invade the soft tissues, primarily of the cortex. He holds that in many, if not most, cases their invasion begins in the seed tuber which is decomposed, and then proceeds through the sprouts or stems originating from this infected tuber. In frequent cases, however, the infection may occur in the subterranean parts directly from the soil, such lesions appearing as discolored areas on any part of the stem below ground including the tuberiferous stolons or the tubers themselves. In this way the tuber bearing stems may be cut off and the tubers themselves rotted. Exactly such lesions were observed upon some stem bases in the station field, and in a few cases upon the tuberiferous stolons. Most of the cases under observation in the present case were, however, too far advanced in decay to permit satisfactory conclusions as to their origin. Rolfs describes like lesions as due to *Rhizoctonia*, but our observations failed to convince us that as the trouble occurred here, *Rhizoctonia* was present or active in any unusual way in the affected parts.

The fact that the seed tubers were so generally decayed in this field and that this is also the case in the typical German

Schwarzbeinigkeit, as described by Appel and as the writer saw it in both Germany and England, is worthy of careful attention. Appel believes that in his bacterial disease the causal germs are carried on or in the seed tubers as a rule. It was at first suspected that the explanation of the outbreak in question was to be sought here. Further observation failed to justify this conclusion. The seed tubers used were, as previously stated, of the Green Mountain variety obtained in Maine, and were apparently in first class condition when secured. They were all disinfected by immersion in a solution of formalin as is customary to guard against the scab.[1] About two acres was planted with this seed. The soil was all a clay loam. Most of it had good surface drainage and on this portion there was little or no black-leg. The trouble was principally confined to one corner of the field in which the drainage was relatively poor.

The present judgment of the writer favors the conclusion that the trouble as it occurred in this case, therefore, was primarily associated with the heavy and rather wet condition of the soil in this part of the field. It seems altogether probable that the early decay of the seed tuber was associated with bacterial, or perhaps fungus, invasion, and that these invaders advanced from the decaying seed tuber to the bases of the stems arising therefrom. The present observations lead to the belief, however, that these organisms were able to accomplish this invasion only under conditions unfavorable to the normal development of the potato, i. e., in the wetter, heavier soil. While seed disinfection is, therefore, a thing to be recommended as a safeguard precautionary against such possible infection as it is against scab, yet attention to soil conditions is of more fundamental importance. In the present case it seems more probable that whatever organisms were associated with the trouble, whether bacterial or fungus, were already present in the soil rather than introduced with the tubers.

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[1] Two hours' immersion in a solution of 1 pound of formalin in 30 gallons of water.

Appel reports that a soft rot of the resultant crop of tubers is regularly or, at least, very frequently associated with the malady in Germany, and his *Bacillus phytophthorus* was originally found in such rotten tubers. All the hills showing black-leg were staked and these as well as the crop in the field in general was carefully examined for rot when dug, but not a single rotten tuber was found nor has any rot developed in storage among these up to mid-winter. These facts lead one to doubt the full applicability of Appel's conclusions to the disease as it occurred here, although in its general aspects it is the same thing. However, the writer is prepared to accept Appel's explanation of this malady as at least the best working theory at present available.

Harrison[1] has just published an account of a bacterial rot of potatoes which may have some relation to this also, although there is nothing in his account to indicate the identity of the maladies.

In conclusion it is desired to record evidence that the black-leg type of disease may be produced by fundamentally different causes. During the summer a number of plants in different fields were found which had the characteristic diseased appearance of black-leg plants i. e. yellowing, weakened foliage, partially erected branches and uprolling leaves, in which the trouble was clearly not in any way associated with bacterial or fungus parasites. In several cases the sides or bases of the stem had been killed by paris green, which had been carelessly applied in excess. This was a field where pure paris green had been applied dry with a powder gun, and where enough of the poison was lodged on the lower parts of the stem to be clearly seen with the naked eye. Other cases were observed where examination showed that the cortex of the stem at or near the surface of the ground was broken or eaten away thus girdling the stem. Evidently this had been done in some cases at least by the disturbance attendant upon cultivation. These foliage symptoms may

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[1] Harrison, F. C., Centrbl. f. Bakt. II Abt. XVII, p. 34 *et seq.* (1906).

doubtless be brought about by anything which injures or destroys the soft tissues of the basal part of the stem without corresponding injury to the woody tissues.

POTATO SPRAYING EXPERIMENTS

L. R. Jones and N. J. Giddings

In continuation of the policy of this department for a number of years, trial sprayings of potatoes were made with various compounds.

These were carried on in duplicate in two fields; one a sandy loam, the other on heavier clay loam. In both cases the variety was Green Mountain, planted May 22 in the clay field, and May 27 in the other. As already explained, there was no late blight or rot in either of these fields. The early blight was quite prevalent on the sandier field during July and August. Aside from the relation to the control of this malady, any beneficial effects derived from the practice of spraying must be credited to the reduction of insect injuries and to the indirect or tonic effect of the compounds used.

There were a number of trials planned, the value of which depended upon the prevalence of the late blight and rot. Inasmuch as that did not occur, report on these trials would be without significance and is omitted. With the others, upon which report follows, there were two aims: first, to learn the gain from the use of bordeaux mixture; second, to learn the relative values of various commercial articles offered by the Bowker Insecticide Company.

Rows were staked out in each field for this purpose, the plots in general being 11 rods long and 3 rows in width. In two cases where it was necessary to vary these proportions slightly the yields have been computed on the basis of this size so as to facilitate comparisons.

GAIN FROM THE USE OF BORDEAUX MIXTURE

Trials looking to the determination of this gain have been made annually for 16 years, and the methods and results have been discussed in detail heretofore. Only a brief presentation, therefore, will be made here. In all cases the plants were treated alike with insecticides previous to the experimental spraying. After the spraying began, the plots constituting the controls were dusted with paris green mixed with 20 parts by weight of air-slaked lime, aiming to use about 1 to 1½ pounds of the paris green per acre each application. In all cases the bordeaux consisted of 1 pound of copper sulphate and 1 pound of lime to 10 gallons of water, with 1-10 of a pound of paris green added. The amount used averaged 130 gallons per acre at each application. The beneficial effect of bordeaux was evident in lessening the early blight, especially on field A, in reducing insect injuries and in its general tonic effect. It was not practicable under the conditions even to estimate the relative proportion of the total gain attributable to each of these factors.

Two applications were made on field A, one on August 13 and another on August 22. There were four applications made on field B, July 18 and 27, August 8 and 22.

The results were as follows, the yields being stated in pounds per plat:

FIELD A—SANDY LOAM

	Total yield	Marketable tubers	Small tubers
Bordeaux mixture and paris green..........	355 lbs.	308 lbs.	47 lbs.
Control; paris green and lime.............	278 "	234 "	44 "
Gain from bordeaux mixture.........	77 "	74 "	3 "

This equals a gain of approximately 28 percent in total yield, and 31 percent in marketable crop.

FIELD B—CLAY LOAM

	Total yield	Marketable tubers	Small tubers
Bordeaux mixture and paris green..........	248 lbs.	161 lbs.	87 lbs.
Control; paris green and lime............	142 "	96 "	46 "
Gain from use of bordeaux mixture...	106 "	65 "	41 "

This equals a gain of 74 percent in total yield and 68 percent in marketable crop.

The gains on plat B are naturally the greater, since this was sprayed more times. The other conditions were unfavorable, however, for a fair interpretation of the results, since this was in a moist part of the field and there was a considerable "black-leg" trouble on these plants. These factors combined materially to reduce the yield and make the stand somewhat irregular. In comparing the results of 1906 with those of preceding years, we prefer, therefore, to take those from field A. Since each plot contained 6.2 square rods it is easy to calculate the yield on the acre basis as in preceding years. Doing this, the record for 16 years stands as follows:

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre where sprayed	Yield per acre where not sprayed	Gain per acre
White Star,	May —, 1891	Aug. 26, Sept. 8,	313 bu.	248 bu.	65 bu.
" "	May 20, 1892	July 30, Aug. 13, 25,	291 "	99 "	192 "
" "	May 20, 1893	Aug. 1, 16, 29,	338 "	114 "	224 "
" "	Apr. 26, 1894	June 16, J'y 17, Aug. 30,	323 "	251 "	72 "
" "	May 20, 1895	July 25, Aug. 13, 31,	389 "	219 "	170 "
Polaris,	May 15, 1896	Aug. 7, 21,	325 "	257 "	68 "
"	June 1, 1897	July 27, Aug. 17, 28,	151 "	80 "	71 "
White Star,	May 10, 1898	July 21, Aug. 10,	238 "	112 "	126 "
Average, 3 varieties,	May 18, 1899	July 26, Aug. 17, Sept. 8,	229 "	161 "	68 "
Delaware	May 23, 1900	Aug. 4, 23,	285 "	225 "	60 "
"	May 25, 1901	July 20, Aug. 21,	170 "	54 "	116 "
"	May 15, 1902	Aug. 1, 20,	298 "	164 "	134 "
Green Mount.,	May 1, 1903	Aug. 10,	361 "	237 "	124 "
Delaware,	May 25, 1904	Aug. 1, Sept. 1,	327 "	193 "	134 "
"	May 15, 1905	Aug. 2, 21,	382 "	221 "	161 "
Green Mount.,	May 27, 1906	Aug. 13, 22,	133 "	101 "	32 "
Average of 16 years,			285 "	171 "	114 "

A COMPARISON OF THE BOWKER SPRAY COMPOUNDS

The Bowker Insecticide Company sent to this Station for trial the following compounds: "Copper phosphate," "Dust Bordeaux," "1-2-3." The last named material contains arsenical

compounds and is put forward as a combined insecticide and fungicide; the first two are recommended as fungicides only. These articles were tested on the two fields already described. Five applications were made of each, viz.: on July 6, 18, 27, August 8 and 22. Since potato beetles were quite troublesome, paris green was added to the copper phosphate and dust bordeaux at the rate of about a pound and a half to the acre. The amounts of each used averaged as follows per application:

Copper phosphate	13	lbs.
Dust bordeaux	17	"
1-2-3	10	"

On one-half of each plot the application was made dry, i. e., scattering the powder upon the plants while they were still moist with dew. On the other half of the same row the powder was in each case mixed with water at the rate of 1 pound of powder to about 5 gallons of water, and applied as a spray.

The result as shown by the appearance of the plants was favorable to all these compounds. The general appearance of the vines was slightly better where the compounds were applied in water, but the yields of tubers showed no material difference as between the wet and the dry applications. The application of 1-2-3 proved promptly effective in freeing the plants of the Colorado beetles, and, of course, the others as reinforced by paris green did so. All proved good deterrents to the flea beetle. We judge that their action against this latter pest is like that of various similar compounds [1] heretofore tested at this Station, due to the fact that they render the treated plants objectionable to the insect rather than that they act as poisons. None of these compounds, however, proved equal to the bordeaux mixture against the early blight. Apparently these compounds like bordeaux mixture exerted some tonic influence. Unfortunately for the value of the trial no late blight occurred. Final judgment as to the relative fungicidal value of these compounds must, therefore, be reserved.

[1] Vt. Sta. Bul. 44, p. 94 (1894).

The average yields from these plots were as follows, stated in pounds:

	Total yield	Large tubers	Small tubers
Copper phosphate	198	141	57
Dust bordeaux	216	151	65
1-2-3	216	163	53
Paris green and lime	210	165	45

The relatively low yield from copper phosphate, as shown above, is not in the writers' judgment attributable to any inherent inferior quality of this compound, but, rather, to unfavorable soil conditions upon one portion of the field.

This trial was unsatisfactory in several particulars, one being, as already explained, the appearance of the black-leg disease in field B and the consequent reduction in the yield. The distribution of this disease was such that it apparently affected all of the plots about alike; but, of course, such an occurrence reduces one's confidence in the experimental value of data obtained under such conditions. It seems justifiable to conclude, however, from these trials that 1-2-3 is a safe and reliable insecticide, that none of the compounds are liable to injure the potato foliage in any way, and that all exert some tonic effect aside from their fungicidal and insecticidal relations. Judgment as to their relative value as fungicides must, of course, be reserved until further trials shall have afforded data upon which it may be based.

ALFALFA CULTURE IN GRAND ISLE COUNTY

L. R. JONES AND H. A. EDSON

The popular interest in alfalfa culture which led to the publication of bulletin 114 of this Station in the spring of 1905 has persisted and in some sections spread. This is especially the case in Grand Isle county. It was noted in that bulletin that alfalfa was succeeding in a larger percent of cases in the Champlain valley than elsewhere in Vermont and that this success

had been especially encouraging in a section of Grand Isle county. This has led to the following up of those trials which were being made by the farmers unaided and to the placing of lots of seed from various sources in this neighborhood for further comparative trials.

THE SOIL AND CLIMATIC CONDITIONS IN GRAND ISLE COUNTY

For the benefit of readers unfamiliar with local geography it should be explained that Grand Isle county consists of the three large islands, Grand Isle, North Hero, Isle La Motte, and the adjacent Alburgh peninsula which lie in the north end of Lake Champlain. The county takes its name from the largest of these islands, Grand Isle, and most of the following observations were made thereon.

The soil and climatic conditions of Grand Isle county are somewhat different from those of the mainland. Its low altitude and proximity to a large area of water make the climate more equable, hold back vegetation in the spring and keep off early autumnal frosts. The beneficial results are well shown by the higher degree of success generally attained here than on the mainland with such fruits as pears, plums, etc.

Doubtless the chief reasons, however, for the comparatively greater success with alfalfa in this county than elsewhere in the state are to be sought in soil rather than in climatic condition. While in general topography the islands have no high elevations, yet the land is gently rolling so that there is fairly good natural surface drainage. Even more significant is the evidence as to underdrainage due in part to the admixture of gravel and shaly stones in the surface soil and in part, probably, to the open character of the substrata. The region includes, geologically, Chazy and Trenton limestone formations and Utica shales with outcroppings of Black River strata. These insure a strong basal soil rich in lime and with a good potash content also, which, coupled with proper underdrainage, affords an excellent type of alfalfa soil. This is especially characteristic of the low ridges which occur frequently where the slaty shales often come to the

surface, and the soil has a larger admixture with gravel. It is noteworthy that several of the best pieces of alfalfa are found on these situations. Some are, however, on lower and wetter soils where there is no such evidence as to underdrainage.

EARLIER TRIALS OF ALFALFA IN GRAND ISLE

So far as has been learned, Mr. S. G. Macomber has had the longest experience in alfalfa culture in Grand Isle. Some 17 years ago, i. e. about 1889, a small field was seeded by him to grass and clover, and there was an unintentional mixture of alfalfa seed in the clover. This formed scattering alfalfa stools in the field which have persisted to the present time with no apparent diminution in number. The soil is a gravelly clay loam, rather moist, but so sloping to the northwest that no water stands long on the surface and no ice forms on it in winter.

In 1901 Mr. Macomber sowed two and a half acres of rather poor gravelly clay loam, using 20 pounds seed per acre with oats as a nurse crop. The land had been badly infested with quack or witch grass, *Agropyron repens,* which had been partially but not wholly removed by raking out the roots. The alfalfa did well for the first three years keeping the quack grass pretty well subdued until 1904-05 when it winter killed somewhat, due in part the owner thinks to the fact that he cut it late, after frost came and growth was stopped, leaving it with too little winter protection. Since then the witch grass has been gaining. About 50 percent of the stand is still alfalfa. This will be plowed soon, put in cultivated crops to subdue the witch grass and then reseeded to alfalfa. Since the first year this field has been cut twice annually and then pastured, except the one year (1904) when it was cut a third time. The annual yield of hay from the two cuttings has been bountiful, estimated at five tons per acre.

In 1904 Mr. Macomber sowed 5 acres more. This was on rather poor soil, slaty surface, underlaid with gravelly clay, having a gentle westerly slope and good natural drainage, both surface and subsoil, so that no water or ice stands on the land. It was sown about the middle of April, using 20 pounds of alfalfa

together with 2 bushels of oats per acre. This crop has done well. It was not cut in 1904 after the removal of the grain, but has been cut twice each year since (i. e., 1905 and 1906). The yield of hay was bountiful, being estimated at five tons per acre. It has been pastured each autumn. There has been no winter killing, the stand being practically perfect this autumn (1906). The only fault to be found is that the stand is not quite thick enough, and Mr. Macomber believes that 30 pounds of seed per acre would have been better. This last spring, 1906, he sowed another one acre piece immediately adjoining this with northern Montana seed furnished by the Station, using 30 pounds per acre. This has now a perfect stand which promises to be thick enough.

Mr. E. J. Parker has also had a long and successful experience in alfalfa culture. He first sowed a small piece in 1898, using Utah seed, with oats as nurse crop. This has given good yields, being cut three and some seasons four times until this year, when it has succumbed to quack grass, and will be plowed up.

Encouraged by this success, Mr. Parker sowed in 1904 10 acres on a clay soil with slaty subsoil of good natural drainage, seeding in April with oats, 20 pounds alfalfa per acre. He simply cut the grain the first year but cut alfalfa three times in 1905, the yields being estimated as follows: June 26, 2.5 tons; July 27, 2 tons; Sept. 15, 1.5 tons; total, 6 tons. In 1906 it was cut at almost exactly the same dates and the yields were estimated the same as in 1905. The stand this autumn (1906) is practically perfect, there having been only a very little winter killing and that in spots where water stood on the surface. No serious trouble was experienced with weeds, except with a little dodder which was killed out by salting. Mr. Parker has shown his appreciation of the crop by sowing six acres more last spring (1906), using 25 pounds alfalfa with oats as nurse crop. He has a good stand from this seeding.

Of the many other residents of the county who have had similarly successful experience, special mention can be made of only a few.

Mr. H. C. Allen sowed an acre in 1901. He got a perfect stand and cut two big crops each year from 1902 to 1905, estimated at fully four tons per acre. In 1905-6 there was some winter-killing in the lower parts, so it was plowed in the summer of 1906 after cutting one crop, planted to corn and will be reseeded to alfalfa in the spring of 1907. In 1904 he sowed two acres more on poor gravelly clay loam with good natural drainage, using oats as nurse crop and 20 pounds of seed per acre. The stand was uniformly good save that it was a little too thin. It has since been cut twice each year, 1905 and 1906, the total yield being estimated at over four tons per acre. He could cut a third crop annually but as the land is poor and this ridge liable to winter exposure he prefers to let this later growth remain as a winter protection.

Mr. Edward Gordon sowed 3.5 acres in 1904, on gravelly clay soil, with good natural drainage except in one corner where water is apt to collect on surface. He seeded 16 pounds alfalfa per acre with barley as nurse crop. He pastured it the first autumn without apparent injury and cut it three times in each 1905 and 1906 (last week in June, last week in July and middle of September), the total yields being estimated at nearly five tons per acre. In 1906 Mr. Gordon sowed five acres more on similar soil and followed the same general methods save that it has not been pastured. There appears (fall 1906) to be a perfect stand in this field.

Mr. James W. Hoag sowed five acres in April, 1904, on gravelly clay soil with good natural drainage so that practically no water stands on the surface, using oats as nurse crop. Twenty pounds alfalfa and three bushels of oats per acre were used. Nothing was done to it after removal of grain first year. In 1905 it was cut thrice, the total yield being about 3 tons per acre. The piece was top dressed with 250 pounds of commercial fertilizer per acre immediately after second cutting (about Aug. 1), a strip left without this treatment showing that it was of much benefit. Similar results were attained in 1906, the top

dressing being repeated, 200 pounds per acre in spring and 50 pounds August 1. There is now (fall 1906) a practically perfect stand in this field. The only improvement would be to have it a trifle thicker from use of a little more seed.

Since these cases have served to illustrate the details as to methods practiced in the most successful alfalfa culture in the island county it simply remains to summarize the other data secured in tabular form on the opposite page.

Putting together the evidence obtained from those who have tested alfalfa is Grand Isle county the following conclusions are reached.

Every man who has tried alfalfa on proper soil has had fair success. Every one without exception pronounces it a profitable crop to grow. Almost every one considers it the most profitable crop he can grow on certain types of soil. The soils where it is succeeding best are gravelly or slaty clay loams with good natural underdrainage and gently sloping so that no water stands on the surface. Nearly all the winter killing is attributed to standing water or to the formation of a surface sheet of ice.

The methods of culture which receive the endorsement of the Grand Isle alfalfa growers of most experience are as follows:

1. Thorough preparation of the soil, especially as to freeing it from quack grass.

2. Seeding with grain in the spring as early as the ground can be worked. Oats is most commonly used as a nurse crop but barley is preferable. While under highly favorable circumstances success has been secured from seeding in June and without a nurse crop, this is not considered a reliable method.

3. Twenty pounds of alfalfa seed per acre has been the usual amount, and even less has given a successful crop under favorable circumstances. In general, however, the appearance of the fields indicates that a little heavier seeding will prove better, that twenty-five or, better, thirty pounds is advised and is being used by several in their later sowings. Most of the seed used has been purchased in the general market and is of un-

TABULATED SUMMARY OF ALFALFA CULTURE IN GRAND ISLE

NAME	Year sown	Acres	Nature of soil	Drainage	Season when sown	Nurse crop	Pounds of seed per acre	Weediness	Treatment, first culture	Times cut annually	Pastured in autumn	Average total yield per acre	Stand in autumn, 1906	Remarks
Allen, H. C.	1901	1	*a	fair	Spring	Oats	17			2	no	4 tons	......	*1
" " "	1904	2	"	good	"	"	20			2	"	4 "	100%	*2
Childs, E. W.	1906	1	"	fair	"	"	40	yes		....	....	....	100%	*3
Gordon, Edward	1904	3½	"	good	April	Barley	16	dodder	pastured	3	no	5 tons	100%	*4
" "	1906	5	"	"	May 5	"	17			....	....	....	......	....
Griswold, Henry C.	1905	¼	"	fair	April	Wheat	20			3	no	4 "	......	*4
Griswold, Homer E.	1903	1	....	....	Spring	"	....			3	"	6 "	good	....
" " "	1905	1	*a	good	June	none	20			3	"	4 "	"	....
Hoag, J. W.	1904	5	"	"	April	Oats	20	dodder		3	"	8 "	"	....
Kinney, C. C.	1905	2¼	"	"	"	Wheat and Oats	20			2	"	4 "	100%	....
Ladd, H. W.	1904	1½	*b	"	June	Buckwheat	15			2	"	2½ "	60%	*5
" " "	1905	3½	"	fair	June 1	none	20	quack	pastured	1	yes	....	poor	*6
Macomber, S. G.	1901	2½	*c	"	Spring	Oats	20	dodder and quack	"	2	"	5 tons	"	*6
" " "	1904	5	*b	good	April	"	20	dodder		2	"	5 "	100%	....
" " "	1906	1	"	"	"	"	80			....	....	....	100%	....
Parker, E. J.	1898	....	....	....	....	"	....	....	....	....	....	....	......	*7
" " "	1904	10	* c	good	April	"	20	dodder		3	no	6 tons	100%	....
" " "	1906	6	"	"	Spring	"	25			....	....	....	100%	....

INDEX TO REMARKS

*1. 25% winter killed in 1905-06. Plowed up in June, 1906, to reseed to alfalfa in 1907.
*2. A little too thin. Mr. Allen would use 30 pounds of seed per acre.
*3. Stand good except under trees, where it is poor.
*4. Winter killing where the water stood.
*5. Winter killing where the ice formed on surface.
*6. Killed out by quack grass.
*7. Small trial plot. Did well till last year, when quack grass ran it out.

INDEX TO SOILS

*a. Gravelly clay loam.
*b. Slaty loam.
*c. Clay loam.

known origin, presumably from the southwestern states. The United States Department of Agriculture and this Station are uniting in the introduction of northern grown seed for trial in this section. While no experimental evidence of value is yet secured it seems probable that such seed will prove to be hardier than that from further south.

4. No further treatment is given the crop during the first year after the grain is harvested, although some have pastured that autumn without apparent injury.

5. The crop is cut is succeeding years, generally three times annually, when in early blossom (emphasis is laid by the most experienced growers upon cutting *early*). This makes the dates of cutting (1) the last week in June; (2) the last week of July, and (3) early in September. On poor soil or exposed places the third cutting may more safely be omitted. In any case is should not be delayed too late in the autumn. Mr. Macomber and some other successful growers pasture the fields in the autumn instead of cutting the third time. The majority consider that cutting the crop is preferable to pasturing it.

6. A light annual top dressing with commercial fertilizer has given excellent results where practiced.

7. No harrowing, disking or other cultural method have been tried and there is no reason to think that such would be beneficial.

8. Trouble from weeds seems confined to quack and dodder. The soil must be nearly or quite free from quack grass that the young alfalfa plants may get a foothold the first year. Once established, however, the alfalfa seems capable on these soils of keeping the quack in subjection unless it is much weakened or killed in winter. Dodder has frequently been introduced in the seed. It does not show much if any the first year but develops rapidly and does its greatest damage the second year. It can be killed out by cultivation, by smothering with straw, by the liberal use of salt, or by applying kerosene and burning; but by all these methods the alfalfa as well as the dodder

is killed. Since the dodder will kill the alfalfa anyhow and moreover will continue to spread, the right way is to watch for it early the second summer and to destroy it promptly when seen. Fortunately it does not seem to have matured seed in any of the cases known to the writers in Vermont and it largely dies out of itself the second winter. A little has been seen to develop the third year, however, and where this occurs it should, of course, be promptly eradicated.

In all these cases the crop is cured as hay, none being ensiled. It is often thus treated in the west, making a very desirable silage. Doubtless a good disposition of the crop cut as late as mid-September would be to mix it in the silo load for load with corn provided the latter is cut thus early.

According to Grand Isle evidence alfalfa is but little more difficult to cure than red clover. Some use the tedder but in general it is considered better not to use it as it breaks off many leaves. The best practice seems to be to cut in the forenoon, to let lie in the swath 24 hours, then to rake and cock up the second day before it is fully dry, thus preserving all of the leaves, and to complete the curing by leaving in the cock one day or longer. Handled thus, hay of first quality is secured which is eaten clean by cows, sheep and other stock. Horses, poultry and pigs relish it greatly but in general it is so valued for dairy cows it is not fed to other animals. Those who have had opportunity to compare alfalfa and clover hays claim that the former is eaten with less waste and is the better fodder.

Longevity. In only one case has a full stand continued longer than five years. One (Parker's) lasted 1898-1905, but this was only a small field, less than an acre, and hence not as conclusive a trial as if on larger scale. Two pieces of one acre or more (Macomber and Allen's) sowed in 1901 stood well until 1906 when being partially run out they were plowed with the intention of reseeding to alfalfa soon. A large number of pieces sowed in 1904 have almost without exception proved perfectly successful to date, and the general verdict is that *the crop is so*

desirable that were it entirely killed out this winter yet would it be considered a profitable crop and its culture would be continued.

SOIL INOCULATION—ROOT TUBERCLES

The highest success with alfalfa and related leguminous crops is dependent upon the presence of the nitrogen gathering bacteria in tubercles upon their roots. Examinations in several fields have shown these to occur in Grand Isle and there is no reason to doubt that they are general there. Inasmuch as experiments elsewhere have shown that the organisms found on the sweet clover (*Melilotus*) are identical with those on alfalfa, it is worth while to note that this clover occurs frequently as a spontaneous growth throughout Grand Isle county. Probably its occurrence is to be regarded as a fair index of natural adaptation to alfalfa.

No soil or seed inoculation has been practiced by Grand Isle growers generally and there is no evidence that it is needed. Experience in New York and elsewhere indicates that where it is needed the best method is to scatter 100 pounds or more per acre of soil from an old alfalfa field.

In view of such results as these it is evident that there is every reason for encouragement as to the prospects for permanent success with alfalfa on favorable soils in Grand Isle county, probably elsewhere in the Champlain valley, and possibly in various other parts of the State. Certainly those who have suitable opportunity should continue to experiment with this crop. Attention in all such cases should be given to the selection of a suitable location, of a well drained soil, and to careful preparation of the seed bed.

Quantity of plant food. Seventy-seven percent of the brands met their guaranties. Eight brands failed to afford a commercial equivalent of their promises. Five out of six goods sold by one company proved deficient in one or more ingredients, as did the entire output (three brands) of another company. The former case was reported for prosecution to the state's attorney of Windsor county.

Quality of plant food. The quality of the crude stock used in manufacturing the goods was found on the whole to be all that could be wished. A few criticisms, however, may be made. Nearly one-half of the brands, mostly the low grade and low priced goods, carried no water-soluble nitrogen. An inferential claim, that sulphate of potash was used, appears on nearly two-thirds of the brands; only five brands contain any appreciable quantity. The organic nitrogen used, with possibly one or two exceptions, seems to have been of good quality.

Selling prices and valuations. The average selling price was $30.57; the average valuation, $21.21. One dollar in three spent for mixed fertilizers was paid to the manufacturer, railroad, and selling agent for their work, while only two of the three paid for plant food. But 61 cents' worth of plant food was bought for a dollar in average low grade goods, and 68 cents' worth in medium grade goods. The average high grade brand, however, afforded 77 cents' worth for a dollar. Some Vermont buyers paid twice as much for plant food as did others.

The analyses of the fertilizers sold in Vermont in 1907 appear on pages 188-203 of bulletin 130.

A comparison of analyses of brands for five years shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods.

A discussion of soil biology in its relation to fertilization occurs on pages 213-276, covering the nature and work of bacteria as a whole and of soil bacteria as a class, with particular reference to their relations to soil nitrogen, to nitrification, denitrification and nitrogen fixation.

THE OCCURRENCE OF PLANT DISEASES IN 1907

N. J. Giddings

The wet, cloudy weather which prevailed in the latter part of the spring and early summer favored the development of many plant diseases. Certain maladies, however, which are dependent upon midsummer moisture received a severe set-back during the latter part of July and August, when occurred a considerable period of hot, dry weather. The recurrence of rainy weather during September revived some of the dormant parasites, but they did not thereafter cause much damage since the season was so near its close. These late rains, on the other hand, were of considerable benefit to farm crops.

POTATO DISEASES

Insect injuries. The Colorado beetle and flea beetle were very destructive where not properly held in check. The former, as is well known, is easily controlled by paris green used alone or in connection with other materials; but the latter is not appreciably affected by the paris green, either when used alone or when mixed with lime. The bordeaux-paris green combination, however, was very effective in combating both beetles.

A large number of seedling potato plants were destroyed by wire worms in one experimental field, the entire base of the potato stalk frequently being destroyed by their perforations.

Tip burn and sun scald. These two similar physiological diseases are not of great importance by themselves, but associated with insect and fungus injuries the former is sometimes the cause of considerable loss.

Sun scald is apt to occur when several days of wet, cloudy weather are followed immediately by two or three hot, dry days. Very little sun scald was seen in 1907, but the amount of tip burn was unusually large. Tip burn usually results from a long,

hot, dry spell. Working in conjunction with the early blight and flea beetle it caused considerable loss during the drouth of last midsummer. Those experimental plots which were sprayed with bordeaux mixture showed much less of the trouble than other plots.

Early blight. This disease, due to the fungus *Alternaria solani*, was quite destructive in many fields. The dry weather of midsummer favored its development, and it was especially in evidence upon light sandy soils. Observations led to the conclusion that during the past summer on many fields as much as one-sixth of the total active leaf surface was thus destroyed. Since any factor which diminishes the living leaf surface proportionately reduces the tuber yield, it is clearly evident that the early blight was responsible for a very considerable amount of loss in 1907. It is a well demonstrated fact that spraying potatoes with bordeaux mixture proves a quite effective check to this trouble; and there were only one-third to one-half as many badly diseased leaves this year on the bordeaux plots as on the check plots.

Leaf blotch. This disease, caused by *Cercospora concors*, was described in detail in the last report.[1] It was found again in the small experimental plot where it was first seen and where it has been watched for two years; but the development there was of minor importance. A much more severe outbreak was found in a field near the Experiment farm, where a few diseased leaves were noted in 1906. Potatoes were again planted in this field in 1907 and a great many leaves were practically covered with the leaf blotch fungus. The occurrence was confined to a small portion of the field so that actual loss was not important. In the account of this fungus given in the last report[1] it was recorded only as occurring on the potato. This year (1907) it was found (by L. R. Jones) near Burlington on the solanaceous weed, *Solanum dulcamara*. This weed was growing in a thicket remote from

[1]Vt. Sta. Rpt. 19, p. 236 (1906).

tilled land. It raises the question as to whether the fungus, hitherto assumed to be introduced from Europe, may not be native.

Late blight. The late blight fungus, *Phytophthora infestans,* did but little damage in this immediate vicinity. The September rains were, however, very favorable for its development and it was found in several fields about Burlington. Considerable loss occurred in the central portions of the state nearer the mountains, and in other states the disease caused great loss. Favorable weather conditions next year will insure its destructive development where potatoes are not properly sprayed. Bordeaux mixture is the best known preventive preparation.

Scab. This trouble, due to the fungus*Oospora scabies,* was prevalent in many fields. Planting in new soil and disinfecting tubers with formalin just previous to planting have been found effective in controlling this disease.

Black leg. The results of several years' observation upon this disease appear in the last report.[1] Several tubers taken from diseased hills last year (1906) were planted on a sandy loam soil in 1907. These made a normal growth and not a single diseased hill appeared among them. A plot of Beauty of Hebron potatoes immediately adjoining these showed, however, quite a number of hills affected with the typical "black leg." The Beauty of Hebron seed was secured from a local dealer at the time of planting. Two other varieties planted in the same field, one adjoining the Beauty of Hebron, showed no traces of the malady. Reports were received of black leg from Maine and Massachusetts. Specimens secured from Maine resembled in appearance those collected here. A Massachusetts correspondent states that the disease occurs with him most frequently with new seed, and that he rarely finds any the second year after such introduction. It is not easy to reconcile these conflicting observations. The writer inclines to the belief that as a rule this disease is carried on or in the seed tubers, but that its destructive development is largely determined by soil conditions.

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[1]Vt. Sta. Rpt. 19, p. 257 (1906).

ORCHARD DISEASES

Apple canker, caused by the fungus *Sphaeropsis malorum,* is still quite prevalent in some orchards. It is easily controlled by pruning and spraying and is thus kept down in most well tended orchards.

Black knot of plum was more destructive than usual this season. The fungus *Plowrightia morbosa* was favored in its development by the long continued spring rains. This disease is easily held in check when proper attention is given to pruning and spraying.

Brown rot of the plum, due to *Sclerotinia fructigena,* caused considerable loss among susceptible varieties. Wherever the plums hang in clusters touching one another the development of the rot is favored. The spores of the fungus are washed down in rains and any which chance to lodge between two plums that touch are apt to be held there, and find conditions favorable to growth. If one plum of a cluster is seen to be diseased it should be destroyed at once, as others in the cluster are almost sure to go if the rotting one hangs long in contact with them.

GARDEN DISEASES

The violet leaf spot caused by *Marsonia violae* was briefly described in the last report.[1] The disease has more troublesome this year than previously and seems a serious pest on violets out of doors. It has not been reported from any new localities during the past year. No remedial measures have been tried as yet other than the removal of diseased leaves, but spraying experiments are proposed for the coming season.

Club root. This disease, due to *Plasmodiophora brassicae,* was widespread as usual the past season. It is troublesome to market gardeners in various portions of the State, and the losses must continue to increase until greater care is exercised to prevent its dissemination. Cabbage plants should be started in soil which has not been previously used for cabbage culture. A

[1]Vt. Sta. Rpt. 19, p. 234 (1906).

field in which the disease is found should be kept free of cabbage, turnip, and kale, and other weeds of the mustard family for several years, since the fungus lives over in the soil and thrives on any plants of this family.

Muskmelon anthracnose. This disease, due to the fungus *Colletotrichum lagenarium,* did considerable damage in market gardens. The September rains favored its spread and a large share of the melons in local gardens were affected. Melon leaves badly diseased by this fungus were received from correspondents. This trouble is present every year to a greater or lesser extent, but the loss is generally small. Spraying with bordeaux mixture about the first of July and every two weeks thereafter until the middle or latter part of August is very effective in its control.

Muskmelon rot. Specimens of diseased muskmelons were received on September 14 from E. S. Brigham, St. Albans. The melons were of the "Montreal" variety and grown for the fancy market. A considerable development of soft rot occurred among these toward the close of the season. This generally began on the lower side of the fruit. The interior flesh was completely decayed around the point of infection and possessed a disagreeable odor. The skin has shrunken over the diseased area, but generally remained unbroken. Microscopic examination proved that the decayed tissue swarmed with motile bacteria, that the cells were detached from one another and that their contents were in most cases destroyed. Poured plates were immediately made from melons in the early stages of decay. Numerous bacterial colonies appeared thereon within thirty hours, and both transfers and inoculation were made from these at the end of this time. The transfers were made first so as to secure the organisms in pure culture, and then an inoculation made from the same colony. Forty-eight hours later the decay was well under way in the melons thus inoculated. Four melons were also inoculated from pure cultures on September 18th. Three days later all these melons had diseased areas at the point of inoculation ¾ inch to 1½ inches in diameter. In one of these which was

opened the decay had penetrated to the cavity. Plates were again poured from one of these melons and cultures secured similar to the original ones. Nine cucumbers and about twenty more muskmelons were inoculated with pure cultures of the organism during the early autumn and the following preliminary conclusions[1] are drawn from the field observations and the results thus secured by inoculation.

The malady is a bacterial soft rot and the specific organism a wound parasite. Its rapid spread in early September was due to the fact that a period of summer drouth was followed by one of excessive rain. The rapid growth thus stimulated led to numerous ruptures of the melon skin which permitted the entrance of the organism. The bacillus prefers melons which are not quite ripe, and develops more rapidly in the round than in the elongated type. The decay, starting just under the skin, spreads inward and laterally at about the same rate, forming a more or less conical decayed area with the point of the cone toward the cavity of the melon. As soon as the organisms reach the interior cavity they spread very rapidly throughout the entire melon, which collapses in one or two days thereafter. Melons were almost always completely decayed in from three to five days after inoculation from pure culture.

The organism caused decay of cucumbers in some cases, but the action was much slower and only one-third of those inoculated gave evidence of the disease. The organism itself is an actively motile bacillus averaging about 1.6x.8 microns and having several peripheral flagella 6 to 8 microns in length. The colonies are spreading and grayish white upon agar plates. In agar stab cultures the surface growth is grayish white and wet-shiny, while there is considerable clouding in the medium along the line of puncture. Gelatin is liquified quite rapidly for three or four days and then liquefaction proceeds very slowly until it is complete. There is a dense white sediment in the liquified gelatin. Milk is coagulated in two days at 26° F.; litmus milk

[1]Further and more complete studies of this organism are under way.

is coagulated in two days and shows slight acid production in three days, and bleaching in nine days without further evidence of acid production; and there is very slight gas formation in both milk and litmus milk in nine days. The growth on cooked potato is yellowish, raised, and wet-shiny, while there were several bubbles of gas produced at the base of potato tubes, where there was some moisture. Shaken cultures in glucose, saccharose, and lactose agars gave good growth, but no sign of gas production. The surface growth was much the strongest upon the saccharose agar. There was a slight production of indol in Dunham's peptone solution, and abundant nitrite production in nitrate broth.

FOREST DISEASES

Damping off of coniferous seedlings was troublesome in early summer in the seed beds of the State Nursery. A special account on this appears on page 342 of this report.

Pine blight, an obscure disease of the white pine, has been prevalent for several years past. Its cause is at yet undetermined, but is being investigated by the Bureau of Plant Industry of the United States Department of Agriculture.

POTATO SPRAYING EXPERIMENTS

L. R. JONES AND N. J. GIDDINGS

Experimental trials of fungicides upon potatoes have now been carried on at this Station for 17 consecutive years. Those of 1907 were designed to bear upon the following points:

I. The relative gain from spraying potatoes with bordeaux-paris green and the comparative results from 2, 3 and 4 applications of the mixture.

II. The relative gains from the use of the commercial compounds, Boxal and Bug Death, as compared with bordeaux mixture and with paris green.

THE GENERAL PLAN OF THE EXPERIMENTS

These experiments were conducted on a level sandy loam fairly uniform in its character. The potatoes were planted in drills three feet apart, and 18 inches apart in the row. The entire field was given clean culture. Each row as staked off for the experiments was 100 feet long. Ten such rows of Ionia Seedling and as many of Green Mountain potatoes were planted May 21; and the remainder of the field was planted to Green Mountain potatoes in the course of the next week. The trials were planned primarily with a view of testing the fungicidal value of the various compounds above mentioned, but, as has been learned in previous years, certain insects and fungi come at about the same season and it is impracticable clearly to differentiate in some cases the gains due to fungicidal effects from those due to insecticidal or other action. All of the compounds used held the Colorado beetle in check. The flea beetles were present as usual and did considerable damage where not controlled. It will be seen that much of the difference in results is due to variations in the degree of control of these pests.

The early blight fungus (*Alternaria solani*) occurred destructively and distinct evidence was obtained as to the relative fungicidal value of the various compounds as against this malady. The late blight fungus (*Phytophthora infestans*) was not detected on the experimental rows, so none of the gains can be attributed to its control; and there was no rot whatever in the crop of tubers. With these preliminary explanations the discussion of the details as to the special experiments may be begun.

THE GAIN FROM THE USE OF BORDEAUX MIXTURE

Trials have been made by the senior writer since 1891 to determine the gain from use of bordeaux mixture on potatoes. This compound has been shown to have beneficial effects in three distinct ways: fungicidal, insecticidal (as an insect deterrent), and tonic. These factors vary from year to year, therefore, the results vary; but in every trial heretofore made the spraying has proved

distinctly beneficial. The bordeaux mixture used was of the 5-5-50 formula, made in the proportion of 5 pounds copper sulphate, 5 pounds lime and 50 gallons water, and was mixed fresh for use. To this was added one-half pound of paris green for all applications except the last (August 22) when, the insects having disappeared, this poison was omitted. The first two applications were made at the rate of 150 gallons per acre, the last two at the rate of 200 gallons. The control rows alongside were poisoned with paris green alone at the same dates that the above mixture was applied. The paris green was mixed with air-slacked lime at the rate of one pound of the poison in 20 pounds of lime and applied at the rate of 30 pounds per acre. The trials were made upon Green Mountain potatoes planted about May 25. There were three rows in each plot and the plots were so planned as to test the benefits obtainable from spraying with bordeaux mixture at various dates as follows:

Plot 1. Bordeaux applied four times, July 16 and 25, August 8 and 22.
Plot 2. Bordeaux three times, July 25, August 8 and 22.
Plot 3. Bordeaux two times, August 8 and 22.
Plot 4. Control, paris green in lime.
Plot 5. Bordeaux four times, July 16, 25, August 8, 22.
Plot 6. Control, paris green in lime.
Plot 7. Bordeaux three times, July 25, August 8, 22.

In each plots 2, 3 and 7, paris green was applied at the earlier dates in order to hold the Colorado beetle in check. The beneficial effects of the bordeaux mixture became apparent in early August and were increasingly evident the latter part of this month and through September. This was the more noteworthy since there was no trace of the late blight; the benefits being due to the control of early blight and insect troubles, save in so far as the less definite physiological effects were of help. The latter were operative, however, as shown by the relatively richer green of the sprayed foliage and the lessened amount of tip-burn.

In order to get more definite data as to the relation of spraying to flea beetle and early blight injuries, critical examinations as to these points were made on September 6. For this purpose typical plants were selected in each plot and counts made of those leaflets badly diseased with early blight and of those having a considerable number of punctures made by flea beetles. Taking the average of several such counts results were found as follows:

	Leaflets badly eaten by flea beetle	Leaflets badly diseased with early blight
Bordeaux twice, Aug. 8, 22	95%	75%
Bordeaux three times, July 25, Aug. 8, 22	55	45
Bordeaux four times, July 16, 25, Aug. 8, 22	48	40
Paris green in lime	97	80

It must be borne in mind when considering these results that the degree of mutilation or disease was not susceptible of exact measurement and that the estimate necessarily is based upon the judgment of the observer. Yet even allowing a considerable margin of variation in judgment the results are striking and conclusive. The two bordeaux applications made August 8 and 22 were evidently ineffectual to a large degree as a check to the flea beetle or the early blight. The July sprayings were the ones which chiefly prevented these two pests from obtaining their foothold in the field.

The yield in pounds per plot of three rows 100 feet long is given in the following table:

	Large tubers	Small tubers	Total yield	Gain in market'le tubers over check	
				Pounds	Percent
Plot 1. Sprayed four times	218.8	41.6	260.4	138.8	172.5
Plot 2. Sprayed three times	158.4	47.6	206.0	78.4	98.
Plot 3. Sprayed two times	154.3	51.8	206.1	74.3	92.9
Plot 4. Check paris green	80.0	56.9	136.9	.....	.....
Plot 5. Sprayed four times	165.1	50.4	215.5	79.8	93.5
Plot 6. Check paris green	85.3	59.5	144.8	.....	.....
Plot 7. Sprayed three times	130.0	56.3	186.3	44.7	52.4

The gain in plot 1 over 2 was 54.4 pounds or 26%, and in plot 5 over 7 was 29.2 pounds or 16%. It is evident, therefore, that with the conditions that prevailed last year the first spraying, made about the middle of July, was of much importance. It is probable that three thorough sprayings made about July 15, August 1 and August 15 would have done about as much good as these four. The experience of recent years has served to emphasize the dictum that all things considered the first application of bordeaux mixture should be made about the middle of July. Owing to the fact that most potato sprayers apply only 50 or 75 gallons per acre, one must go over the rows twice in order to secure as thorough an application as is here recommended and practiced. If this is done an interval of two or three weeks may elapse between dates of spraying. In actual farm practice, however, it will probably prove better to use the single lighter application and to go over the field more often, i. e., once in a week or ten days. Thus if the first spraying was made the second week in July, four or five such applications would be advisable. If, however, there was a period of moist warm weather and the late blight was threatening it would be advisable to make a thorough application, using at least 150 gallons per acre. With ordinary spray carts it might be necessary at such time to go over each row twice, and in this case one should when making the second application go over the row in the opposite direction from that of the first, so as to cover the foliage more effectually.

The results attained this year afford evidence entirely in harmony with that attained in preceding years. Some years the gain is large, in others it is smaller; but in any case it pays to spray and so to insure a full crop. This will become the more evident by comparison of the results during the past 17 years.

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Planted	Sprayed	Yield per acre		Gain per acre
		Sprayed	Not sprayed	
White Star,				
May —, 1891	Aug. 26, Sept. 8,	313 bu.	248 bu.	65 bu. or 26 %
May 20, 1892	July 30, Aug. 13, 25,	291 "	99 "	192 " " 194 "
May 20, 1893	Aug. 1, 16, 29,	338 "	114 "	224 " " 196 "
Apr. 26, 1894	June 16, July 17, Aug. 30,	323 "	251 "	72 " " 29 "
May 20, 1895	July 25, Aug. 13, 31,	389 "	219 "	170 " " 78 "
Polaris,				
May 15, 1896	Aug. 7, 21,	325 "	257 "	68 " " 26 "
June 1, 1897	July 27, Aug. 17, 28,	151 "	80 "	71 " " 89 "
White Star,				
May 10, 1898	July 21, Aug. 10,	238 "	112 "	126 " " 112 "
Average, 3 varieties,				
May 18, 1899	July 26, Aug. 17, Sept. 8,	229 "	161 "	68 " " 42 "
Delaware,				
May 23, 1900	Aug. 4, 23,	285 "	225 "	60 " " 27 "
May 25, 1901	July 20, Aug. 21,	170 "	54 "	116 " " 215 "
May 15, 1902	Aug. 1, 20,	298 "	164 "	134 " " 82 "
Green Mountain,				
May 1, 1903	Aug. 10,	361 "	237 "	124 " " 52 "
Delaware,				
May 25, 1904	Aug. 1, Sept. 1,	327 "	193 "	134 " " 69 "
May 15, 1905	Aug. 2, 21,	382 "	221 "	161 " " 73 "
Green Mountain,				
May 27, 1906	Aug. 13, 22,	133 "	101 "	32 " " 32 "
May 1, 1907	July 16, 25, Aug. 8, 22,	171 "	63 "	108 " " 175 "
Average of 17 years,		278 "	165 "	113 " " 68 "

A COMPARATIVE TRIAL OF BOXAL, BUG DEATH AND BORDEAUX-ARSENICAL MIXTURE

Numerous inquiries have come to the Station during the past year for further advice as to the value for use on potatoes of the commercial preparations known as Boxal and Bug Death. Trial plots of 10 rows each were therefore laid off for treatment as follows: Two rows Bug Death, two rows Boxal, two rows bordeaux mixture, four rows paris green. There were two such plots to be treated in this way; one planted with Ionia Seedling and one with Green Mountain potatoes.

As previously explained, the bordeaux mixture was of the 5-5-50 formula and paris green was added to this at the rate of one-half pound of poison to fifty gallons of the mixture. The first three applications were at the rate of 150 gallons per acre and the last two at the rate of 200 gallons.

The control plot was dusted with paris green in lime, one pound of the poison to 20 pounds of the lime, and this was applied at the rate of 30 pounds per acre. The Bug Death and Boxal were mixed with water at the rate of one pound to 10 gallons. It has been found in our experience necessary to apply Bug Death very liberally in order to keep the plants free from Colorado beetles. The amounts used averaged at the rate of 25 pounds to the acre, and of Boxal at the rate of 19 pounds to the acre. Each application was so used that the Colorado beetles were held in check on all the plots. It should be emphasized, however, that the primary aim in this work was to test the relative efficacy of these compounds against the other insects, chiefly flea beetles, and as fungicides and general tonics. We therefore made liberal applications and continued them at regular intervals through the summer, regardless of the special need so far as concerned the simple control of the Colorado beetle. All the preparations except Boxal were applied five times at the following dates: July 9, 15, 26, August 8, 22. The manufacturers were unable to supply the Boxal in time for the first application, so paris green was applied on July 9 to the rows designed for Boxal. This arrived July 13, application was promptly made and repeated along with others, on July 15. A marked beneficial effect was apparent during late August and September on all the plots treated with the spray compounds over the check plots. This effect, however, was much more apparent on the bordeaux plots than on any of the others. On September 6 leaflet counts were made to determine approximately the relative damage by flea beetle and early blight. These counts were made in the same way as the counts made on the large Green Mountain plot and previously described. The following results are averages of counts made upon the two varieties of potatoes:

Treatment	Leaflets badly punctured by flea beetle	Leaflets badly diseased by early blight
Bug death	52 percent	47 percent
Boxal	60 "	60 "
Bordeaux	37 "	32 "
Paris green and lime	95 "	88 "

These results give clear evidence that the Boxal and Bug Death are quite effective in checking the flea beetle and early blight. It is, moreover, noticeable that the early blight was checked to a somewhat less degree than was the flea beetle. The bordeaux was much more effective than either of the other preparations for controlling both the flea beetle and early blight.

On September 30 a count was made of those plants which still had living leaves, i. e., such as gave promise of further appreciable gain in tuber formation. The following table gives the average results from the two sets of plots:

Bug death	17 percent of plants alive
Boxal	4 " " " "
Bordeaux	68 " " " "
Check (paris green)	0 " " " "

These figures show a considerable range of difference, but the most important point is that the plants sprayed with bordeaux have a much larger percent of living leaves than those treated otherwise. At the time of digging (Oct. 11) the plants were all dead in every plot except those treated with bordeaux. The following tables give the yield in pounds for two-row plots 100 feet long:

Treatment	Large	Small	Total	Gain as compared with check in marketable tubers	Loss in marketable tubers as compared with bordeaux
			GREEN MOUNTAIN		
Boxal,	155.0 lbs.	23.5 lbs.	178.5 lbs.	72.6 lbs.= 88.1%	15.7 lbs.= 9.2%
Bug death,	137.9 lbs.	26.1 lbs.	164.0 lbs.	55.5 lbs.= 67.4%	32.8 lbs.=19.2%
Bordeaux,	170.7 lbs.	18.0 lbs.	188.7 lbs.	88.3 lbs.=107.2%	
Check (paris green),	82.4 lbs.	19.1 lbs.	101.5 lbs.		88.3 lbs.=51.7%
			IONIA SEEDLING		
Boxal,	133.2 lbs.	56.9 lbs.	190.1 lbs.	28.3 lbs.= 27.1%	29.1 lbs.=17.9%
Bug death,	117.1 lbs.	27.8 lbs.	149.9 lbs.	12.2 lbs.= 11.6%	45.2 lbs.=27.8%
Bordeaux,	162.3 lbs.	43.0 lbs.	205.3 lbs.	57.4 lbs.= 54.7%	
Check (paris green),	104.9 lbs.	41.5 lbs.	146.4 lbs.		57.4 lbs.=35.4%

While the above figures are in general harmony an average secured by combining the results from the two varieties will perhaps make the outcome clearer.

AVERAGE YIELD OF TUBERS OF MARKETABLE SIZE

	Yield of large tubers	Gain over check	Loss when compared with bordeaux
Boxal, ...	144.1 lbs.	50.5 lbs.=54 %	22.4 lbs.=13.5%
Bug death	127.0 lbs.	33.4 lbs.=35.6%	39.5 lbs.=23.7%
Bordeaux-arsenic .	166.5 lbs.	72.9 lbs.=77.9%	....
Check (paris green)	93.6 lbs.	....	72.9 lbs=43.8%

It is clearly evident from the above figures that either the Bug Death or the Boxal is an improvement over lime and paris green, but that neither of them is as good as freshly prepared bordeaux-arsenical mixture. Both of the proprietary compounds have insecticidal and fungicidal value, but they are at once more costly and less effective than the bordeaux.

THE DAMPING OFF OF CONIFEROUS SEEDLINGS

L. R. JONES

This malady is the most serious hindrance to success in rearing seedlings of pine or other conifers in the nursery. It appeared in the station beds in 1906 and again in 1907; and this occurrence is in accord with general experience. The attack is restricted to the early stages of development immediately following germination. Soon after the plants appear above ground the stem tissues brown and shrivel at or below the level of the soil and the weakened plants fall over and wilt. Examination has shown the diseased tissues to be permeated by fungus mycelium. Evidently there is a critical period in the early stage of development of coniferous seedlings when the tissues are unusually susceptible to parasitic invasion.

European publications indicate that more than one fungus may cause this disease. Examinations made of plants from the local beds as well as from those of the New York State nurseries reveal a Fusarium-like fungus similar to one described by Hartig[1] as parasitic on pine and spruce seedlings in Germany, and believed by him to be a Nectria. Pure cultures submitted to Dr. Perley Spaulding of the United States Department of Agriculture were deemed to be the same parasite that he has observed associated with a similar trouble in Missouri and elsewhere. Since both years the beds were located on soil not previously used for coniferous seedlings it seems safe to assume that the fungus is not only widespread in its occurrence but probably a native rather than an introduced species. Admitting this to be the case the development of the disease is apparently conditioned upon three things:

1. Conditions of temperature and moisture as determined by the weather and the mode of handling the shades on the seed beds, etc., during the critical period.

2. Previous treatment of the soil, which may tend to increase or diminish its fungus content.

3. The use of fungicides or other applications upon the beds during the critical period.

Certain observations and experiments bearing upon each of these points will be considered in turn.

First, there is no doubt that much can be done to control this disease by proper management of the beds during the critical period. It is necessary to keep the beds covered in some way until germination begins, but the covering should be removed promptly, thereafter, to prevent slender weakly development of the seedlings. Partial shade is required on bright days, but this should be removed in dull or wet weather to keep the surface soil of the beds from remaining too wet. These are matters which must be left to personal judgment and experience. They become of special importance if a period of warm rainy weather

[1]Hartig, R., Diseases of Trees, Eng. Trans., p. 147 (1894).

occurs during the critical period. The aim then must be to keep the surface of the beds as dry as practicable.

Certain experiences in our beds clearly indicated, however, that the fungus content of the soil at the time of planting is an important factor. This was shown in two ways. Certain beds seeded with Scotch pine in May, 1907, germinated well but damped off badly in June. The first week of July it was decided to try a late sowing of pine seeds. Accordingly new beds were laid out and for comparison one of the beds that had recently damped off was raked over and reseeded. Germination was prompt in both cases. In the bed which had been reseeded practically 90 percent of the plants damped off; in the other, practically none. In the autumn there remained some 20 seedlings per square foot in the former bed and over 200 per square foot in the latter. The beds were in the same field, on quite similar soil, and were handled alike, so that there was no reason to doubt that most if not all this difference was due to the variation in the fungus content of the soil at the time of sowing the beds. This conclusion is in accord with the practice of experienced nurserymen who follow crop rotation in their nurseries.

Accepting this point and admitting also that the fungus is native to our soils, the question arises as to the practicability of disinfecting seed-bed soil. In greenhouse work, soils are advantageously sterilized by steam. This is apparently impracticable out of doors. Recourse was therefore had to the trial of chemicals and formalin was chosen as of most promise. July 3rd, one of the Scotch pine beds, upon which the seedlings had just damped off badly, was raked over preparatory to reseeding. The bed was 4x12 feet in area. It was divided into two compartments by a tight board partition sunk into the soil. One compartment, 4x4 feet, comprising one-third of the bed, was left untreated for control purposes, the other two-thirds was treated with formalin previous to planting. For this trial two strengths were used. This compartment, as stated above, comprised 32 square feet. Upon one-half, 16 square feet, the soil was sprinkled with 10,000 c.c. (approximately 10 quarts) of a 1 percent solu-

tion of formalin in water; the other half received a like application of one-half percent strength. A corresponding amount of water was sprinkled on the control end of the bed and the whole was then closely covered to prevent evaporation. This amount of the solution sufficed thoroughly to wet the soil to a depth of four inches. After 72 hours the bed was uncovered and left exposed to the air for two days longer, the weather being bright and warm the first day, followed by light showers the second. Scotch pine seed was then planted and the beds again covered until germination began, following which the usual care was given all alike. It was soon evident that the formalin was affecting the germination injuriously. The results expressed numerically were as follows:

Total number of seedlings that came up in the control third of the bed	3,200
Total number where sprinkled with one-half percent formalin	2,400
Total number where one percent formalin was used	1,700

Expressed in percentage therefore the one-half percent formalin reduced the stand 25 percent, and the one percent formalin reduced it by nearly 50 percent. This relates to germination merely. Within a few days conditions began to alter. Those pine seedlings which started made as rapid growth in the treated as in the untreated soil. Where no formalin was used the damping off trouble soon set in and by the end of the season practically 90 percent of the plants had perished, leaving a stand of only 320 plants in this third of the bed. In the treated compartment there was also some loss from the damping off. But it was much less, amounting to only 9 percent where the one-half percent formalin was used and 7½ percent where the one percent formalin was used. The resulting stand of seedlings at the end of the season was 2,190 in the portion of the bed treated with one-half percent formalin, and 1,570 in the portion treated with one percent, as compared with the 320 plants in the untreated portion. This outcome encourages the hope, therefore, that with further trials, using other strengths of formalin and with a longer

period between its application and the sowing of the seed, still better practical results may be secured. It is possible that these may be such as to warrant the use of formalin on coniferous seed beds somewhat as Selby advises for tobacco and lettuce soils.[1]

The possibility of control of the disease in the beds by the application of fungicides during the critical period following germination is being investigated in cooperation with Dr. Perley Spaulding of the Bureau of Plant Industry, United States Department of Agriculture. It is evident that some benefit has resulted from certain lines of treatment, but these have not as yet passed the experimental stage.

One procedure is, however, certainly commendable. It is the practice in European nurseries to sprinkle sand on or over the beds immediately following germination. H. V. F. de Thestrup, the station gardener, who has had European experience, advised as to the time and method of this treatment and trial was made of it on various beds. While the gains were not large, it was evident that sufficient benefit was derived to pay well for the application. For example, on one bed of pitch pine seedlings hot sand was applied on a portion of the bed June 27, a part being left untreated as a control. Germination was well along and the damping off had begun to show somewhat before the sand was applied. Consequently the beneficial results were probably less than they would have been had it been made a little earlier. The gain was, however, soon evident to the casual observer. Careful counts made July 15 showed that 42 percent of the plants had damped off on the untreated end of the bed as compared with 30 percent on the sanded part. Similar gains were evident wherever the hot sand was applied. Since it is such a simple, safe and inexpensive proceeding, it is expected to continue the practice of sanding the beds at the State nursery and to advise

[1]Ohio Sta. Cir. 57, 59 (1906). In these it is shown that formalin treatment may reduce the loss from diseases due to soil fungi. Selby's experience leads him to recommend the use of one-half percent strength of formalin (1 pint formaln in 25 gallons water), applying one gallon of this per square foot and then waiting two weeks, before setting plants in the soil.

others to do the same. Clean sand is to be used, preferably of coarse texture, and applied as hot as it can be handled, sprinkling on enough to fully cover the surface of the bed, say one-sixteenth of an inch in depth. This should be done immediately after germination begins.

THE VERMONT STATE NURSERY FOR FOREST TREE SEEDLINGS[1]

L. R. JONES

THE DISTRIBUTION OF SEEDLINGS IN 1907

An immediate effect of the passage of the act establishing a Forest Nursery at the Station was a stimulation of popular interest in the possibilities of forestry plantation. Following the issuance of bulletin 127 requests were received for far more seedlings than were available for distribution. Late requests were entirely declined and large orders filled only in part. Few could have been distributed advantageously in either 1907 or 1908 except for the generosity of the New York Superintendent of Forests, Col. William F. Fox, who permitted the Station to draw upon the surplus stock of the New York State Nursery. From this source about 100,000 seedlings were secured, the larger part being white and red pines with a few Scotch pine. Over one-half of the white pines were at once distributed while the balance of the seedlings were set in the State Nursery. A small nursery was started here prior to the passage of the Act mentioned from which a few thousand white pines were available for distribution. A few native seedlings were also collected as ordered. Finally small purchases were made from commercial nurserymen upon request, the Station acting in the latter tran-

[1]The establishment of this enterprise was discussed in bulletin 127 (April, 1907), wherein it was stated that the last General Assembly passed an act providing that, for a term of five years, five hundred dollars be paid annually to the station to aid in the establishment and maintenance of a nursery for the propagation and distribution at cost of forest tree seedlings; the station to provide at its own expense necessary land and expert supervision.

sactions merely as a means of getting buyers and nurserymen into communication. From these various sources white pine and black locust seedlings were offered for sale in limited amounts as listed on page 46 of bulletin 127, and shipped to twenty parties, five each in Windsor and Orange Counties, three in Rutland, two in Lamoile, and one each in Caledonia, Windham, Chittenden, Addison, and Washington Counties. These were accompanied by directions for unpacking, for setting, and for caring for the seedlings in the nursery row, (soil, beds, spacing, planting, subsequent care and a brief statement as to permanent planting, these being prepared with the advice of the consulting forester and being in accord with the practice obtaining at the New York State Nursery.) It is intended that each shipment of seedlings made from the nursery shall be accompanied by brief but plain directions for guidance. Personal visitation was made to several of the plantations in the fall and their condition noted. In order to secure as complete data as practicable as to the success or failure on the part of those purchasing the seedlings an inquiry was addressed to each purchaser in September asking a series of questions. Answers were returned by all but two purchasers which may be summarized as follows:—

I. Did you receive the shipment promptly? Were the plants apparently in good condition upon receipt?

II. Did you plant promptly, or was there delay between receipt and planting? If so how long, and in what way were the trees stored meanwhile?

III. Did you plant any in nursery row (i. e. in garden or other beds)? If so, give details as to soil, method, distance apart, and care given.

IV. In what condition are these plants now? (Sept. '07).

V. What disposition do you propose to make of these transplants next spring? (i. e. are they part or all to be set in permanent plantation; and if so, what are the soil conditions where plantation is to be made, and how far apart will you set them)?

VI. Did you place any in permanent plantation? If so give details as to soil, method of planting, distance apart, etc.

VII. In what condition are these plants now? State approximate percentage of loss if known.

VIII. Do you plan to fill in 1908 vacancies where any of these seedlings have died? If so, shall you wish to secure plants from the State Nursery? About how many do you estimate you will need for this purpose?

IX. Are you planning to do any planting in 1908 further than is indicated by your answers to preceding questions? If so, what?

X. Have you any suggestions to make, based on your experience this year, which you think will be helpful?

For clearness of presentation the data relative to the locust plantations is summarized by itself under heading B.

A. ANSWERS RELATING TO 2 YEAR OLD WHITE PINE SEEDLINGS

I. In every case the goods were received promptly and in good condition.

II. Two-thirds of the recipients planted the trees within 24 hours of their arrival and most of the others within a week. In one case the plants were kept two weeks and in another three to four weeks before all were planted. In all cases they were trenched or "heeled in." While this longer delay is undesirable it was in no case seriously injurious. For example the party who kept his plants heeled in a trench two weeks before planting reported a loss of but one percent. The party who held part of his plants three or four weeks reported a loss of about ten percent, most of which he attributed to delay in planting.

III. The directions sent out with the 2-year-old seedlings recommended that as the safer policy they be put for one year or more into the nursery row before entering the permanent plantation. It was stated however that where conditions favored they might be placed directly in the field. Most buyers placed all or nearly all of the pines in the nursery row. Some placed part thus and the balance in the field, a few put all in the field. Where set

in the nursery row they were in all cases planted in rows, the distance usually being four to six inches apart, and given clean culture.

IV. Considering the lack of experience and the unusually trying period of dry heat in midsummer the results were gratifying. Two-thirds of the parties reported a loss of less than five percent, which is certainly as low as could be expected, and in one case the loss was only one plant in five hundred. With most others the loss did not exceed ten percent. In cases where it exceeded this sum there was generally evident reason for it; in one case the soil was a dry southern slope and unusually parching heat killed many of the plants before they had established themselves; in two cases a heavy application of commercial fertilizer upon the beds killed many. Fortunately in both cases this was applied to a part of the bed only and the balance did well.

V. Those who set the seedlings in nursery are about equally divided in their plans. About one-half of the plants are to be carried another year in the nursery row and about one-half are to be transplanted to the field this next spring (1908).

VI. Some set a portion and a few set all of their pine seedlings in permanent plantation. One party set them 4x4, the rest 6x6. The grub hoe or spade seems to have been used and no particular difficulty was experienced in setting. The situations planted included worn out hillside pastures, recently cut woodland, or sprout land, and open places in young forest growth.

VII. In spite of the small size of the seedlings and the lack of experience in planting it is encouraging to receive reports of good success from three-fourths of those who tried setting the seedlings in permanent plantations. In general 90 percent of the seedlings have perished. Two expect to collect native stock for lost, due to planting on a dry hillside followed by a severe drought; in another 20 percent were lost because the planted area was in a pasture and the cattle stepped on the plants.

VIII. Practically all of those who started a permanent plantation in 1907 propose to at least fill out vacancies where

Errata—Page 350, 6th line from bottom reading "seedlings have perished. Two expect to collect native stock for." should read "seedlings thus treated lived. In one case the majority were"

seedlings have perished. Two expect to collect native stock for this purpose, the others wish them from the State Nursery.

IX. Perhaps no better evidence can be had of the favorable outcome of the first year's distribution than the fact that three-fourths of those ordering in 1907 and reporting the outcome propose to place another order for seedlings in 1908.

X. Finally several helpful suggestions were made by those who received nursery stock. These included the recommendations (1) that the directions issued urge strongly the prompt planting of stock received; (2) that transplanting be done as early as practicable in the spring; (3) that cattle and other stock be kept off from planted fields; (4) that attention be called to the fact that transplanting native seedlings is a practicable proposition which can be practiced cheaply where they occur plentifully; (5) that great publicity through the press and otherwise be given to the State Nursery offerings and to the desirability of reforesting waste lands.

In addition questions were raised as to the ideal size or age of pine for transplanting, and as to the practicability of planting or broadcast sowing of the pine seed directly upon the land to be reforested. These questions are fundamentally important. Advice based upon experience to date was given in bulletins 120 and 127 and will be again given place in the forestry bulletin of the current year (132).

Summing up the work of the year as regards distribution of seedlings from the State Nursery it is evident that the outcome meets all reasonable expectation. The requests were far in excess of the supply and indicate that the public is ready for the work. Those who purchased seedlings succeeded well with them on the average, showing that it is practicable thus to handle them. Those who made a beginning last year propose in most cases to continue it next year, showing that the movement may be expected to gain in momentum from year to year.

B. LOCUST SEEDLINGS

Some 5,000 locust seedlings were sold through the State Nursery. These are recommended only for small trial plantations by those who wish to grow stakes and fence posts. Since the question of local adaptation and of injury by the borer remain to be answered by experience only small plantations have been recommended. In every case those receiving these seedlings reported them in good condition at the end of the summer. With all but one party they made rapid growth and there was but a small percentage of loss. In this one case many were killed by a severe drought soon after planting. There is no reason to doubt the general practicability of handling locust seedlings.

STARTING THE NURSERY

In addition to securing and distributing pine and locust seedlings as already described the management of the State Nursery has started a number of seed and transplant beds. This was done under the advice of the consulting forester, and following the methods of the New York State Nursery. As a result there are now growing in the beds belonging to the State Nursery approximately 190,000 seedlings and transplants, as follows:[1]

White pine	105,000
Red pine	22,000
Scotch pine	41,000
Other conifers (see list in footnote)	7,000
Locust	15,000

Locusts are best put in permanent plantation when one year old, but pines and other conifers should not be moved before they are two years old, and make stronger growth at three or even four years. Approximately one-fifth of the above listed

[1]The trees are listed in the table under the popular names most commonly used. In order to avoid possible confusion the following synonymy is appended with a statement of native country of each species in parenthesis:

Norway spruce, *Picea excelsa,* (European).
European larch, *Larix Europaea,* (European).
Western yellow pine, *Pinus ponderosa,* (Western U. S.)
Pitch pine, *Pinus rigida,* (native).
Red pine, often called Norway pine, *Pinus resinosa,* (native).
Scotch pine, *Pinus sylvestris,* (European).
White pine, *Pinus strobus,* (native).

material will be available for distribution according to the terms of the law in the spring of 1908. Since the demand of 1908 promises like that of 1907 to be considerably beyond the available supply, applicants will be referred to reliable nursery firms for the filling of excess orders. Definite announcements covering the offerings and prices for the spring of 1908 are now in preparation for issuance as bulletin 132.

Most of the remaining conifers will be available for distribution in 1909. Meanwhile still larger plantings of conifers, especially white pine, will be made in 1908 for distribution in 1910, seed having been collected for this purpose.

The only serious difficulty encountered thus far in the nursery management has been from "damping off," a fungus trouble, in those seed beds which first germinated. This malady was due in part to leaving the shades over the beds a day or two too long, and in part to several days of unusually warm, wet weather, at a critical stage in the development of the seedlings. Profiting from experience with these earlier beds little or no trouble was experienced with the later seed beds. A special statement as to this damping off fungus and the modes of controlling it appears at another place in this report.

COLLECTING WHITE PINE SEED

White pine is a native of America only. It has been cultivated in Europe as a forest tree for many years, chiefly in Germany, and much of the seed offered even in the American market comes from Germany. There is reason to believe, however, that the highest success both in raising the seedlings and in the subsequent growth of the plants is conditioned upon the use of freshly collected seed from our native trees. There is experimental data to show that with some other trees, at least, seed from a more southern source or strain, or from a milder climate, does not produce as hardy stock as does the native or that from a northern locality.

While this has not been experimentally established for the white pine it is at least the reasonable course in this State Nursery

work to use native seed so far as obtainable. Appreciating the fact that 1907 was to be a "seed year" for the white pine in this section the following circular was issued through the press of the State about the first of September.

"The increased interest in forestry in Vermont and all other parts of the country has created an active demand for seed of the common white pine. This matures an abundant crop of seed only once in three or four years, and when a seed year comes the crop must be harvested or one must wait another period of years. This year, 1907, is a seed year in Vermont. Requests are coming to the forestry department of the agricultural experiment station at Burlington from parties, both within the State and outside, who wish to purchase pine seed. This circular letter is therefore issued to the press of the State hoping that it may encourage anyone who is favorably situated to collect the seed. The seeds of the pine are inclosed between the scales in the green cones. As these cones dry and turn brown the seeds fall out. To secure the seed the green cones must be gathered before they open. Usually they begin to open about September 15 or 20, so any collections of the present crop must be made at once. These green cones may now be seen clinging to the tips of the branches at or near the top of the older trees. It is easy to collect them where such trees are being cut down. More usually they are gotten by climbing the trees and with a garden rake pulling off the cones or breaking off the young twigs bearing the cones. These cones may then be gathered into baskets or sacks and spread in a layer not over three inches deep on a clean dry barn floor or similar place under cover to dry, stirring occasionally if need be to insure more rapid drying. If there is a stove in the room the process is much hastened. As the scales open many of the seeds rattle out, and a little flailing brings out the rest. Each seed has a wing. When this is rubbed off and the seeds screened and winnowed each seed is about the size of a large kernal of wheat. Each bushel of cones will yield a pound or somewhat less of such clean seed. The market price of seed this year has not been announced but it is sure to be high enough to pay well for collecting.

The State nursery, which is situated at the Experiment station, will need some seed for its use and distribution each year. Owners of waste land which could profitable be reforested ought if practicable to collect seed for growing their own seedling trees and as before stated requests have been received from those outside of the State, who wish to purchase Vermont seeds. Anyone who can collect seed, therefore, and wishes to dispose of it, or who wishes further advice in the matter should at once

address the Vermont State Forest Nursery, Experiment Station, Burlington, Vermont."

Following this announcement a number of parties undertook, with gratifying results, to collect pine seed. One man collected fifty bushels of cones, and extracted therefrom some fifty pounds of seed. Several others collected smaller amounts. Employees of the State Nursery collected on the University farm fifty bushels of cones from which the seed has been secured. It will be one aim in this movement to encourage more parties systematically to collect pine seed and with the further hope that some may be led to grow the seedlings. When enough have learned to do this, the State Nursery will become unnecessary.

SEASONAL INFUENCE IN CARNATION CROSSING RELATIVE TO SEED PRODUCTION

WILLIAM STUART.

During the past four seasons the writer has studied the seasonal influence in carnation crossing on seed production. The data obtained, coupled with corroborative results secured by Mr. Frank G. Swett a graduate of the class of 1906 in the performance of investigation work for an undergraduate thesis, have served to convince the writer that in the main one may look for maximum success from the early crosses. This does not, however, imply that every similar cross will show a uniform decrease in seed production as the season advances but merely that the average of a number of crosses will gradually diminish in percentage of success and in the number of seed produced.

These conclusions are in accord with those published by Rudd[1] who claims that crosses made early in the season, say November and December, afford a greater percent of successes as well as a larger number of seedlings per capsule than do those

[1]Am. Florist, 23, p. 1046 (1905).

made in January or February. No suggestions however are offered as to the probable causes of success or failure in early and late crossings of carnations, although the inference is that the season of performing the cross is the sole determining factor.

More recently Hall in advocating carnation crossing early in the season gives the following reasons for so doing: "More favorable weather; greater freedom in the production of pollen; plants are then strong while later they are weakened through production, attacks of insects and diseases[1]." The writer believes that these conditions are largely, though probably not entirely, responsible for the differences obtained between early and late crossing of carnations.

Experimental work. Owing to the fact that but a limited portion of the station greenhouse could be devoted to carnations, the number of plants upon which crosses could be made in any season was relatively small. With few exceptions all data secured shows a fairly uniform decrease in seed production and viability of seeds as the season advances. The data obtained each month in each season are presented separately in table 1, save the February successes obtained in 1905.

An analysis of table 1 shows that the data for the month of October only represents one season's crosses, that of November two seasons; December three; January four; and February one. The total number of crosses in the order mentioned are 10, 78, 94, 19. Owing to the fact that October and February crosses are relatively few in number and only represent one season's work it is not possible to attach as much significance to the results obtained as the figures themselves would indicate. In a comparison of the percentage of successful crosses obtained during the months of November, December, and January we find the ratio as evidenced by the following figures to be a gradually decreasing one as the season advances: November 83.3; December 68.1; January 60.8. The omission of the 1905-06 data on percentage of successful crosses is due to the fact that many of the crosses made during that season were with old pollen, which was

[1]Hall, Amer. Carn. Soc. Rpt. 15 (1906).